OCTOBER 12, 1959 PRICE 50 CENTS

Product Engineering

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

- BATTERY-POWERED MOTORS
- PRE-MIX PLASTICS
- PLANETARY FRICTION DRIVE

DESIGN issue

NEW MERCEDES 220-S and its DESIGNERS . . . see page 5

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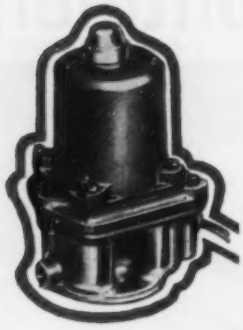

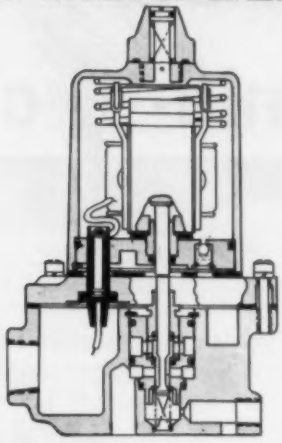

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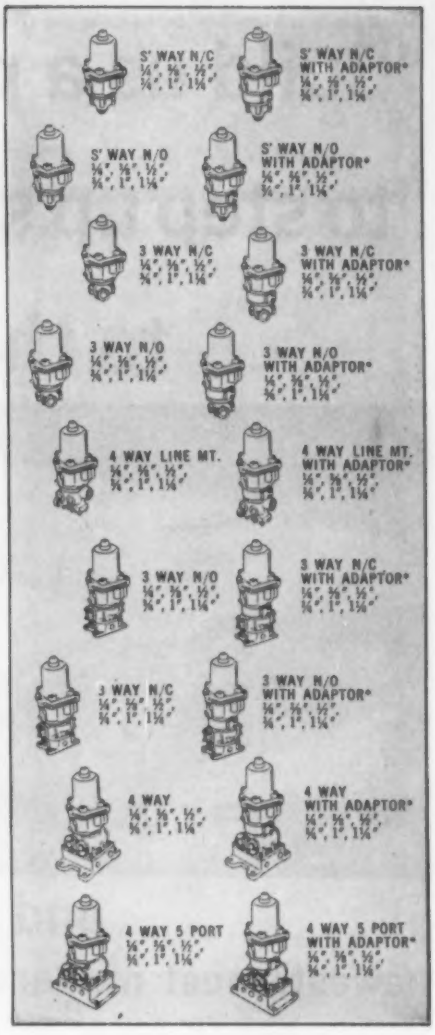
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Product Engineering

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

DESIGN issue

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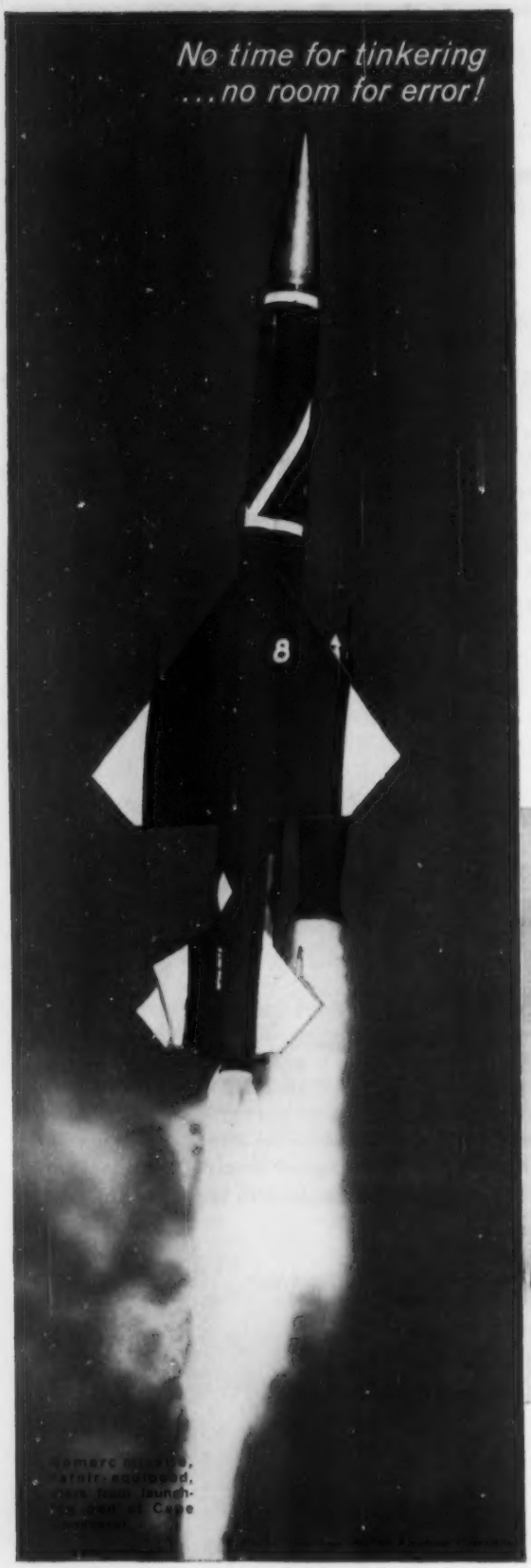

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Interesting to Note . . .

Cars—Here and Abroad

Now is time of year when all the automobile companies are shouting the praises of their respective new products. Again we're being told, "For the first time . . ." or "At long last . . ." or "The newest and finest innovation in automotive design . . ." After listening to Detroit blow its annual horn it becomes difficult for the general public to find out if a new car is ever as revolutionary as the ads indicate. This year, however, Detroit has actually made a radical departure in design. Not only have the "Big 3" shortened the wheel base in their new, compact series; Chevrolet will be the first American car in decades to be pushed instead of pulled (see p 70). An Oldsmobile was once powered by a rear engine. This is why Chevy is not the all-time first of the "Big 3" to claim the distinction.

The engine-in-the-rear concept is certainly not new; many European cars have been so powered for years. In fact nearly all the cars built between 1880 and 1895 had rear engines. Automobile pioneers Gottlieb Daimler and Karl Benz first built their cars with a rear engine (*PE—April 27, p 7*). Now Daimler-Benz is producing a highly successful front-engined car, the Mercedes. Our cover shows this company's new 220-S, together with the five men responsible for its redesign. (Left to right—Rudolf Uhlenhaut, chief of research, development and design; T. Mueller, design development dept; Karl Wilfert, chief, design dept; Prof F. Nallinger, chief engineer and vice-chairman, board of management; F. Ahrens, member, research & design staff.) Uhlenhaut, Wilfert and Nallinger spent six weeks in the United States in 1956 studying American engineering. Two weeks were spent in Detroit.

It's hard to pinpoint the exact causes behind the American shift to the compact car. Imports of foreign cars have been on the increase for several years. When American imports exceeded exports, questions were undoubtedly raised among Detroit's higher echelon. In 1953, General Motors showed a series of "dream cars" in the style of the "sports," which at that time were all imports. Those small Corvettes attracted a lot of favorable attention so Chevrolet decided to go on and market them as a limited-production "specialty" car. By the end of '53, 4000 Corvettes had been sold. Early skepticism about the fiberglass-reinforced plastic body soon disappeared and sales climbed steadily. The '58 sales were about 10,000 units.

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Product Engineering
A McGRAW-HILL PUBLICATION

October 12, 1959 Vol. 30, No. 42

PRODUCT ENGINEERING is published weekly, with an additional Design Digest Issue in Mid-September, by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder. PUBLICATION OFFICE, 99-129 North Broadway, Albany 1, N. Y. See panel right for directions regarding subscription or change of address.
EXECUTIVE, EDITORIAL, CIRCULATION and ADVERTISING OFFICES: 330 W. 42nd St., New York 36, N. Y. Donald C. McGraw, President; Joseph A. Gerardi, Executive Vice-President; L. Keith Goodrich, Vice-President and Treasurer; John J. Cooke, Secretary. Officers of the Publications Division: Nelson L. Bond, President; Harry L. Waddell, Senior Vice-President; John R. Callaham, Vice-President and Editorial Director; Joseph H. Allen, Vice-President and Director of Advertising Sales; A. R. Venezian, Vice-President and Circulation Coordinator.
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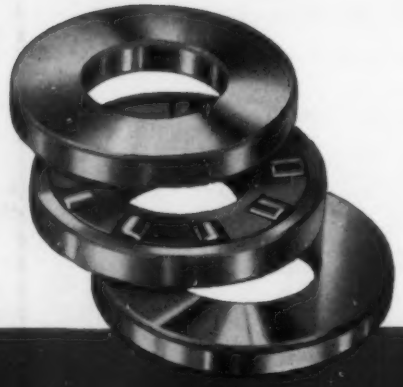

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Interesting to Note . . . (CONTINUED)

The Corvette is America's only sports car, Ford's Thunderbird now being in the 4-passenger "luxury" class. The effect of the new compact cars on the "sports" and small-car market remains for time to decide. A revolution in automobile design and marketing could well be in the making. Public acceptance or rejection will tell Detroit whether it's on the right road.

Revolution on the Farm

A nation's ability to feed itself has been a constant source of domestic and international tension since Eve first ate an apple. It's rather startling that in all the years man has been dependent upon the soil it has been only within the past century that any real agricultural progress has taken place. Perhaps it has been a lack of inventiveness, but more likely the reason behind the lag in farm mechanization has been economic. Operating capital, together with the skills of manufacturing and marketing, are recent innovations. The reaper, for example, is only 130 years old, but with it began a revolution. Not just a revolution of farm machinery, but a new concept of farming, manufacturing and selling.

For five thousand years, the sickle was man's only harvesting implement. Although the scythe and the cradle were employed in some parts of the world, the cutting principle always remained the same. Even when McCormick was working on a harvester his first attempt failed. It was a mechanical scythe which attempted to duplicate the motions of a farmer cutting grain. When his mechanized reaper was successfully developed in 1831, it was soon copied by manufacturers trying to get in on a good thing. Like most revolutionary concepts, the mechanical harvester met hostility from farm workers who feared it would take jobs away from them and also from farmers who just feared change. It took more than a decade before the harvester was finally accepted and its manufacturers began making money. The design story on page 72 shows some new mechanical features never before incorporated in a harvester.

Element Finder

Like so many chemists of the day, Humphry Davy first experimented in the back of the local apothecary shop. Strangely, his teacher wasn't the town pharmacist or physician, but the saddler. Therefore, it is no wonder that some of Davy's later lectures were on the chemistry of tanning and leather work. His book on the chemistry of agriculture became a standard reference book. The wide variety of Davy's personal achievements corresponded with his interests: electricity, chemistry, metallurgy, mining, etc. Poetry was his only hobby that never paid off. Although he wrote verses all his life, the only acclaim he ever received was from Coleridge who attended his lectures in order "to increase his stock of metaphors." Once, Davy shut himself in a room, inhaled nitrous oxide and wrote poetry under its intoxication. Coleridge also tried the gas, with little article artistic improvement.

Davy's interest in electricity prompted him to write a paper, "On Some Chemical Agencies of Electricity." This won for him a 3000-franc prize from the Institute of France in 1807. In itself, this was quite an accomplishment since France and England were then at war. The invention of the miner's safety lamp, called the Davy lamp, was one of the most valuable developments in the mining industry and one that in itself will perpetuate Davy's name.

In 1808, Davy read a paper before the Royal Society, describing a method suggested to him by Berzelius (PE–Sep 28, p 7) of obtaining an amalgam which was called magnesia. He went on to say that the metal whose oxide he had found was a new element. Magnesium (p 74) was not the only element discovered by Humphry Davy. Barium, strontium and calcium also were first isolated by this young Englishman with so many talents.

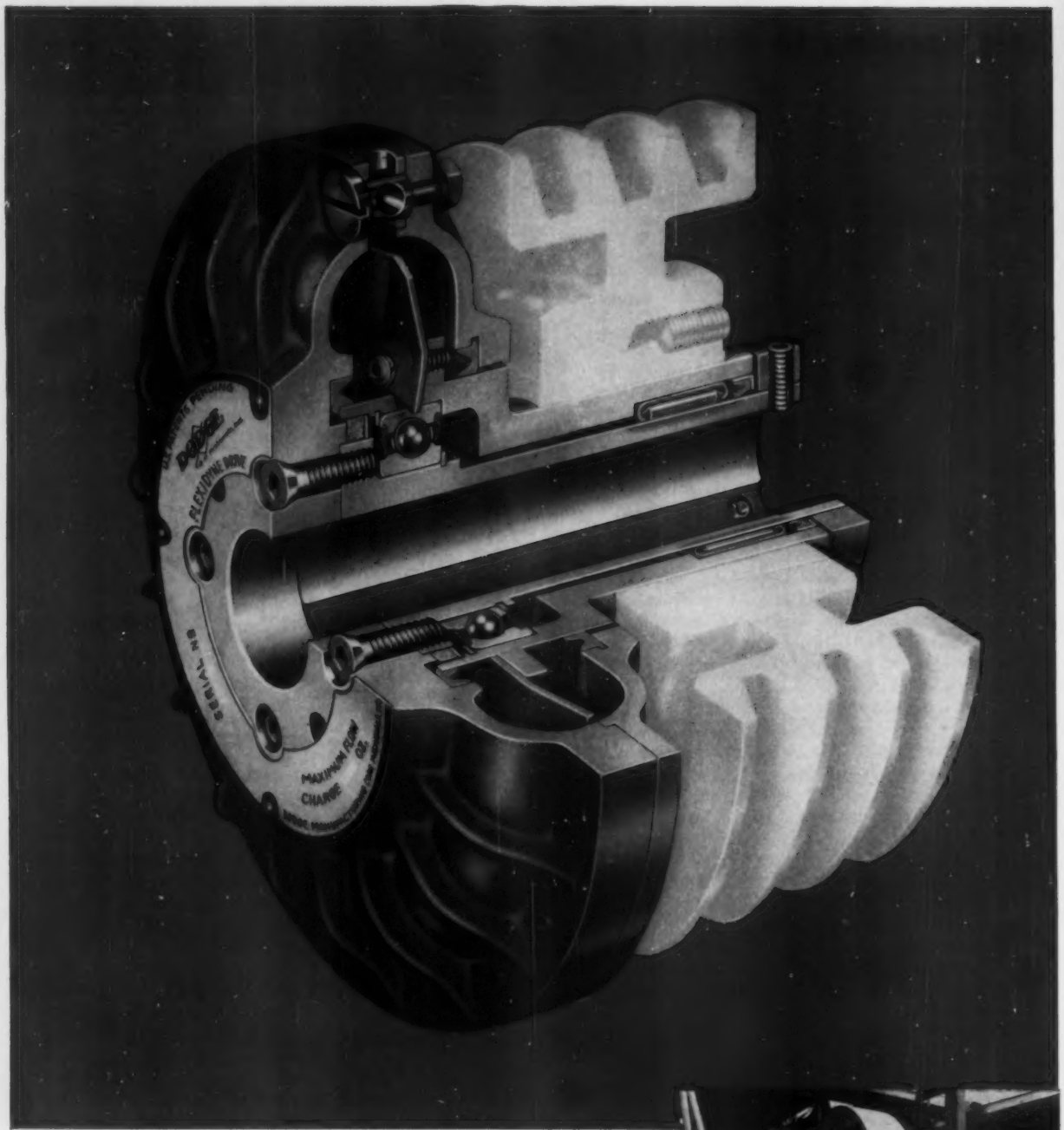
Public Relations—An Ancient Art

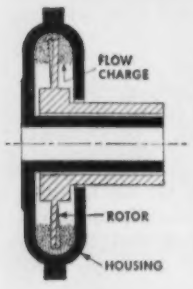
Convincing the people back home that all is well has often been a problem confronting a national leader. With a free network of news dissemination, it's a far more difficult task to conceal the truth than when the people have no way of checking the veracity of what they are told. So it is in parts of the world today; so it was in parts of the world 13 centuries before Christ. Egypt was a world power then, center of science, culture and religion.

Egypt also had a well trained army, directed by Ramses II. This great Pharoah's weakness was his failure to learn about the weapons of his enemy, the Hittites. His Egyptian army was equipped with new spears and the latest bronze shields. What better weapons could the barbarians from the northeast possibly have? Ramses soon found out—in battle. Near the city of Kadesh, now part of Syria, Hittite war chariots plunged through the Egyptian ranks, with the charioteers wielding swords made from a new metal called iron. The performance of iron (p 65) had been put to the test; and Egypt's shields of bronze were split like so many well-dried logs.

When Ramses returned home from the defeat at Kadesh he had a real public relations job on his hands. But he was equal to the job. He asked for and received the hand of a Hittite princess in marriage, then obtained from his new in-laws a supply of iron for the Egyptian army. Ramses also proved that propaganda is an ancient art—his next move was the building of a giant pylon inscribed with a glowing account of his "victory" over the Hittites.

—Benedict A Leerburger Jr





HOW FLEXIDYNE WORKS

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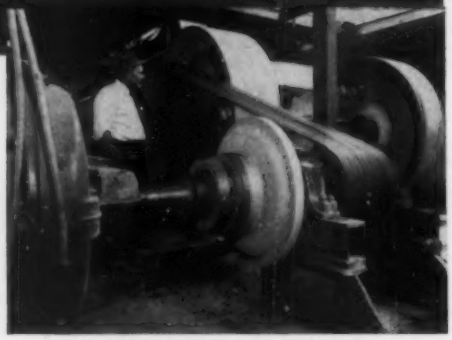

Overloads on a 150 hp jaw crusher cause sudden damage. Here Flexidyne is used to minimize this costly trouble. As a bonus, it reduces belt wear and replacement.

FLEXIDYNE

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Fewer replacements, farther between

...with these LINK-BELT conveyor and elevator chains

LINK-BELT C CLASS CHAIN combines cast malleable center links with steel sidebars connected by steel pins. Broad tops and bottoms provide ample sliding surfaces for drag conveyors. Also available with Promal or "file-hard" Promal center links for extreme loads and abrasive wear. Promal is the special Link-Belt metal that lasts much longer . . . costs but little more.

LINK-BELT SS CLASS BUSHED CHAIN. If your conveyor or elevator must be lengthened, or load increase accommodated, you can install this all-steel chain in place of C Class *without changing sprockets!* It offers hardened joint bearing surfaces for greater wear resistance in heavy-duty conveying and elevating. Smooth, tough joint surfaces repel gritty materials, prevent packing, and resist abrasion.

Full information on these chains . . . plus a broad line of attachments — is contained in Catalog 1050. Get your copy by writing direct . . . or call your nearest Link-Belt office, listed under CHAINS in the yellow pages of your local Phone Directory.

LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,000

DOW | MAGNESIUM

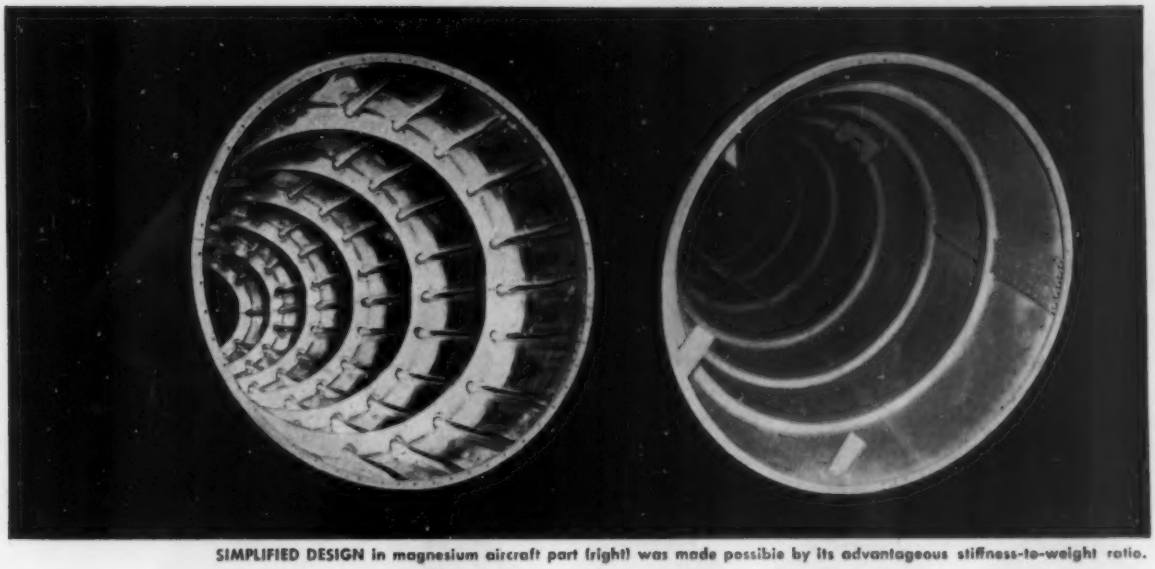
LIGHTWEIGHT DESIGNS

save more than weight

Designers reap a rich harvest of additional benefits as a result of lightness when they use magnesium. Bonuses such as more payload, simplified design, increased performance and reduced human exertion.

People who buy and use the luggage pictured above derive a very direct benefit from magnesium. As this lightweight luggage is made of magnesium, it saves human effort and fatigue. Also, the reduction of weight means more luggage can be carried without extra charge when traveling by air. Magnesium saves human exertion in other products, such as ladders, power tool housings and materials handling equipment.

Another example of the many savings and extra benefits that magnesium —and its resultant load lightening make possible for the designer is in the automotive field. One delivery truck unloads its last parcel and heads for the garage and the gas pump. Another, of identical size, goes on to deliver many



SIMPLIFIED DESIGN in magnesium aircraft part (right) was made possible by its advantageous stiffness-to-weight ratio.

more lbs. of merchandise. Why? The second truck is much lighter–its body is made entirely of magnesium alloy sheet, plate and extrusions. *Because* the second truck is lightweight, it can carry more payload. Or, it can carry the same payload as the first with less fuel, smaller tires and less wear and tear on the engine and transmission. Lighter trucks also save their owners money on license fees, insurance premiums and over-all maintenance.

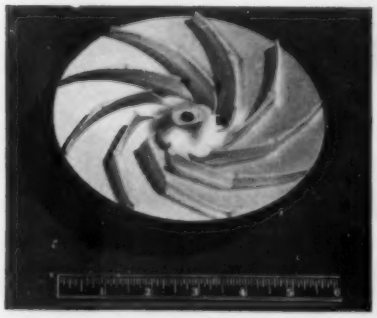
An even more dramatic example is that of missile design. In one ballistic missile, the elimination of *one pound* of excess weight contributes approximately 18,000 feet of additional altitude and a comparable increase in range! This means vastly improved performance wherever magnesium can be substituted for heavier materials.

MAGNESIUM LIGHTNESS INCREASES STRENGTH, STIFFNESS

The designer who is seeking a stiff section can achieve it easily–and still save weight–with magnesium alloys. Magnesium weighs only 67% as much as aluminum, 25% as much as steel and zinc. A structure made of magnesium could be 8 times as stiff as the same part in steel if designed to equal weight. If equal stiffness is the design criterion, a magnesium section can weigh 62% less than steel and 25% less than aluminum.

Aircraft manufacturers have learned to exploit these facts to the fullest in conserving precious airborne weight. Critical parts such as wing and tail structures can be designed with more than adequate stiffness for high speed flying conditions. And, in addition to weight savings, magnesium helps provide a smooth aerodynamic surface and reduces "flutter" and "drag". Most important, the use of more rigid magnesium sections simplifies design by eliminating many of the stringers and stiffeners necessary with other materials.

WRITE TODAY for new brochure, "Magnesium Design". For your copy of this valuable reference for designers, contact the nearest Dow sales office or write to THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Sales Department, 1342DZ10-12.



22,000 r.p.m. HOUSEHOLD ITEM

This die cast vacuum cleaner fan must rotate at 22,000 r.p.m. and have low starting inertia as well as high centrifugal strength. Only magnesium was able to meet the requirements of this specific design. Casting tolerances are held so closely there is no need for balancing.

WORKER FATIGUE THWARTED

A prominent automotive manufacturer uses magnesium paint shields in spraying speedometer panels. The weight saving compared to previous shields resulted in less fatigue, higher efficiency for women employees. The excellent alkali resistance of magnesium permits easy removal of dried paint.

DOW METAL PRODUCTS PRODUCTION FACILITIES

Madison, Ill. plant rolls sheet, plate and coiled strip. It also provides extrusions up to 80' long. The Bay City plants produce high quality sand, permanent mold and die castings as well as lightweight magnesium fabrications. And you get Dow experience and technical service.

THE DOW METAL PRODUCTS COMPANY, Midland, Michigan

DIVISION OF THE DOW CHEMICAL COMPANY

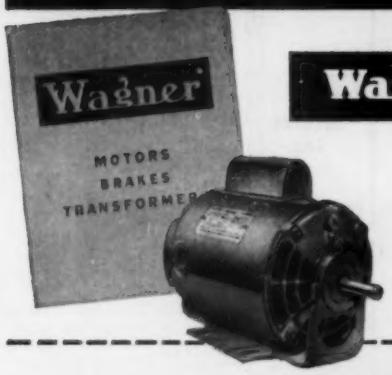
STRENGTH AND UNIFORMITY are outstanding characteristics of the automotive ball-joint bearings shown below. These sintered metal parts demonstrate Moraine Products' capabilities in working with customers to develop the most practical designs. They also demonstrate Moraine Products' responsibilities—making economically, and in quantity, parts that must not fail under the most rugged operating conditions.

Parts shown ½ actual size.

Vital parts for industrial progress

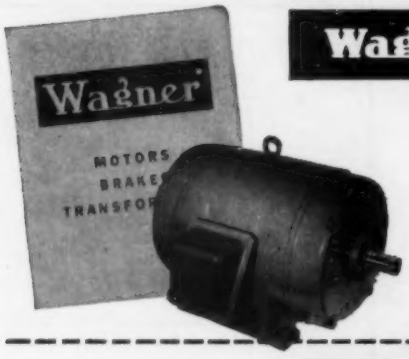
Moraine Products
Division of General Motors, Dayton, Ohio

Which of these ELECTRIC MOTOR BULLETINS can be helpful to you?



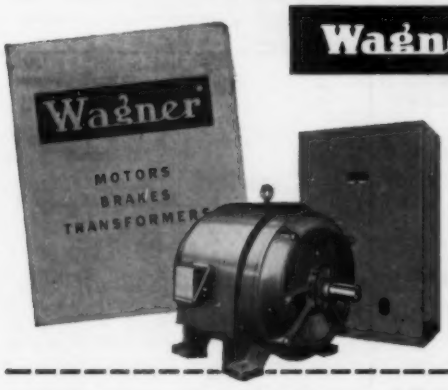
Wagner FRACTIONAL HP MOTORS

Bulletin MU-211. Illustrates and describes both single-phase and polyphase squirrel-cage motors, open and enclosed types; also fan and blower motors and jet pump motors.



Wagner INTEGRAL HP MOTORS

Bulletins MU-212, 213. Cover single-phase ratings through 15 hp, and polyphase squirrel-cage motors through 1000 hp, open and enclosed types; also multispeed, punch press, crane and hoist, and wound rotor polyphase motors.



Wagner MOTOR-STARTER COMBINATIONS FOR REDUCED CURRENT STARTING

Bulletins MU-124, 128, 195. Illustrate and describe the Wagner part-winding motor and starter combinations that limit inrush of starting current in squirrel-cage motors up through 500 hp—meet all starting requirements of AEIC-EEI-NEMA.

In addition to a complete line of standard motors, Wagner also furnishes tube ventilated motors through 500 hp, vertical and flange mounted motors, hermetic motors, gear motors, and direct-current motors. Consult the nearest of our 32 branch offices, or write for specific information on these special application motors.

WM59-19

MAIL COUPON TODAY...
FOR ANY OR ALL OF THESE BULLETINS

Wagner Electric Corporation
6406 Plymouth Ave., St. Louis 14, Mo.

Please send me the following Electric Motor Bulletins:

- ☐ MU-211 Fractional hp Motors.
- ☐ MU-212, 213 Integral hp Motors.
- ☐ MU-124, 128, 195 Reduced Starting Current Combinations.
- ☐ MU-185 All the above material in a single binder.

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COMPANY_____

ADDRESS_____

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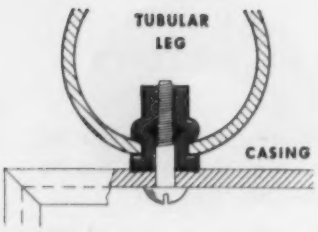
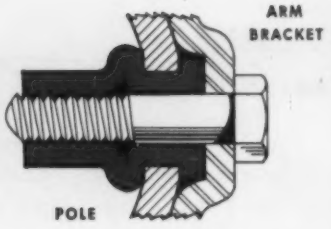
B.F.Goodrich

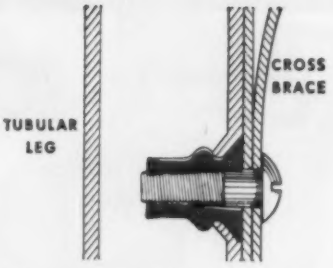
Only B.F.Goodrich Rivnuts® solve all these fastening problems so well



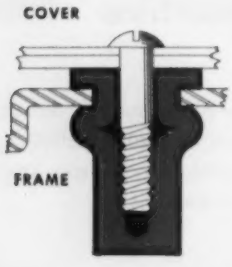
One man installs Rivnuts from one side in seconds—speeds assembly of *barbecues*. Permanent nutplates in legs save time in faster knockdown, too.



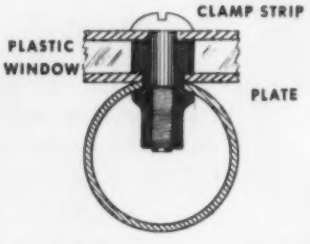
One man does the work of two, assembling arm brackets on *light poles*. Tests show pole or arm will fail before Rivnuts.



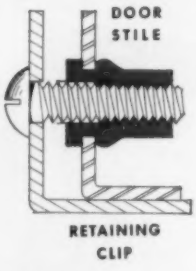
Clean, functional lines of modern *furniture* are preserved by Rivnuts. Upset inside tubular legs, they replace unsightly nuts, bolts and screws.



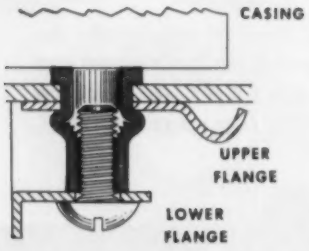
Rivnuts enable repair men to remove top of *automatic washer* and replace it easily. And Rivnuts can be installed after enamelling.



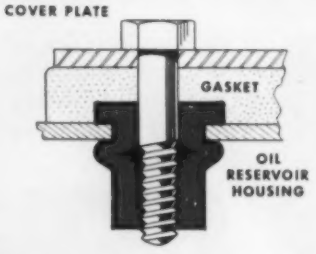
Upset Rivnuts secure *airplane window* plate to center post. Bulges in shanks seal out weather. Heads of Rivnuts serve as spacers for plastic window.



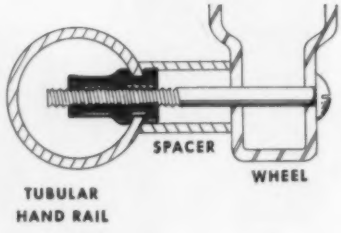
Rivnuts replace self-tapping screws used to hold retaining clips on aluminum *storm doors*, provide firm nutplates that won't loosen with shock or vibration.



Rivnuts eliminate need for reinforcing plates in *vaporizers*. In addition, Rivnuts space bottom flange automatically, prevent bending.



Assembly time for *oil reservoirs* is cut in half. Rivnuts eliminate welding, tapping and cleaning previously required to attach coverplate.



Wheel chair designers needed a blind nutplate with at least 6 clean threads. Rivnuts, only one-piece blind rivets with threads, were the answer.

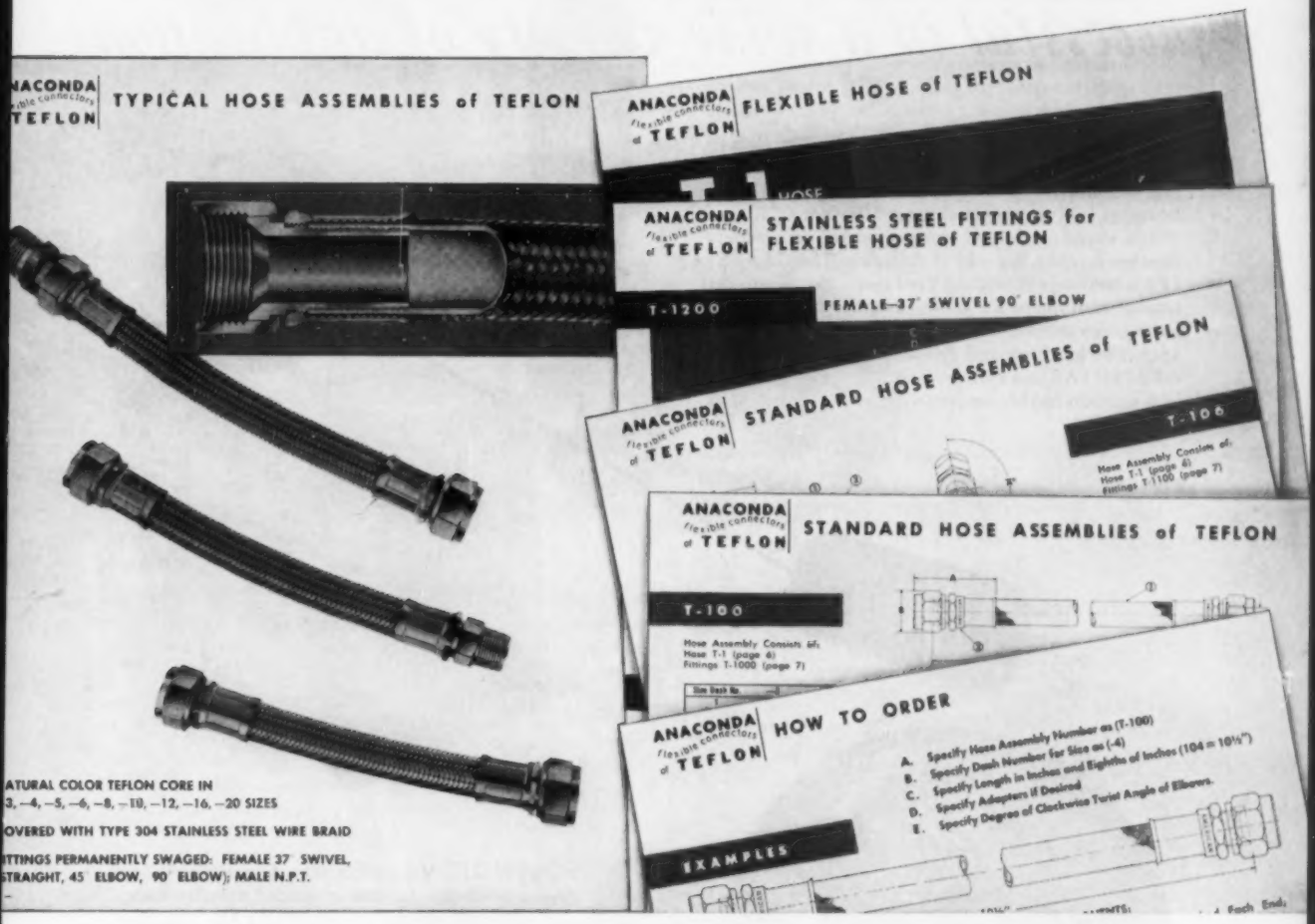
Special fastening problems? B.F.Goodrich Rivnuts solve them. Send for free data book. Dept. PE-109, B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Akron, Ohio.

B.F.Goodrich *aviation products*

CIRCLE 17 ON READER SERVICE CARD→

NEW CATALOG

. . . ON ANACONDA FLEXIBLE CONNECTORS OF TEFLON*


ANACONDA flexible connectors of TEFLON
TYPICAL HOSE ASSEMBLIES of TEFLON
ATURAL COLOR TEFLON CORE IN
3, –4, –5, –6, –8, –10, –12, –16, –20 SIZES
OVERED WITH TYPE 304 STAINLESS STEEL WIRE BRAID
TTINGS PERMANENTLY SWAGED: FEMALE 37° SWIVEL,
STRAIGHT, 45° ELBOW, 90° ELBOW); MALE N.P.T.
ANACONDA flexible connectors of TEFLON
FLEXIBLE HOSE of TEFLON
T-1
HOSE
ANACONDA flexible connectors of TEFLON
STAINLESS STEEL FITTINGS for FLEXIBLE HOSE of TEFLON
T-1200
FEMALE–37° SWIVEL 90° ELBOW
ANACONDA flexible connectors of TEFLON
STANDARD HOSE ASSEMBLIES of TEFLON
T-106
Hose Assembly Consists of:
Hose T-1 (page 6)
Fittings T-1100 (page 7)
ANACONDA flexible connectors of TEFLON
STANDARD HOSE ASSEMBLIES of TEFLON
T-100
Hose Assembly Consists of:
Hose T-1 (page 6)
Fittings T-1000 (page 7)
ANACONDA flexible connectors of TEFLON
HOW TO ORDER
A. Specify Hose Assembly Number as (T-100)
B. Specify Dash Number for Size as (-4)
C. Specify Length in Inches and Eighths of Inches (10⅜ = 10⅜")
D. Specify Adapters if Desired
E. Specify Degree of Clockwise Twist Angle of Elbows.
EXAMPLES

Hose assemblies of Teflon, like those illustrated above, were designed to help meet tough problems—temperature extremes, corrosion, high pressure in conveying chemicals, searching liquids, fuel, oils, oxygen, steam—or in hydraulic and conduit applications. A standard assembly may handle your job, help you cut costs. If not, our laboratory and test facilities, as well as engineering services, are available to help in design and development of hose assemblies for special applications. Let us show you how we can help you handle tough problems with Anaconda Flexible Connectors of Teflon. Send for catalog today. 59126

*Teflon is a DuPont trademark for TFE—fluorocarbon resin

WHEREVER CONNECTORS MUST MOVE

ANACONDA® METAL HOSE

An easy-to-use 16-page book with complete data, drawings, photos

Anaconda Metal Hose Division PE
The American Brass Company
Waterbury 20, Conn.

Please send me your free 16-page catalog of Anaconda Flexible Connectors of Teflon, No. TC-101

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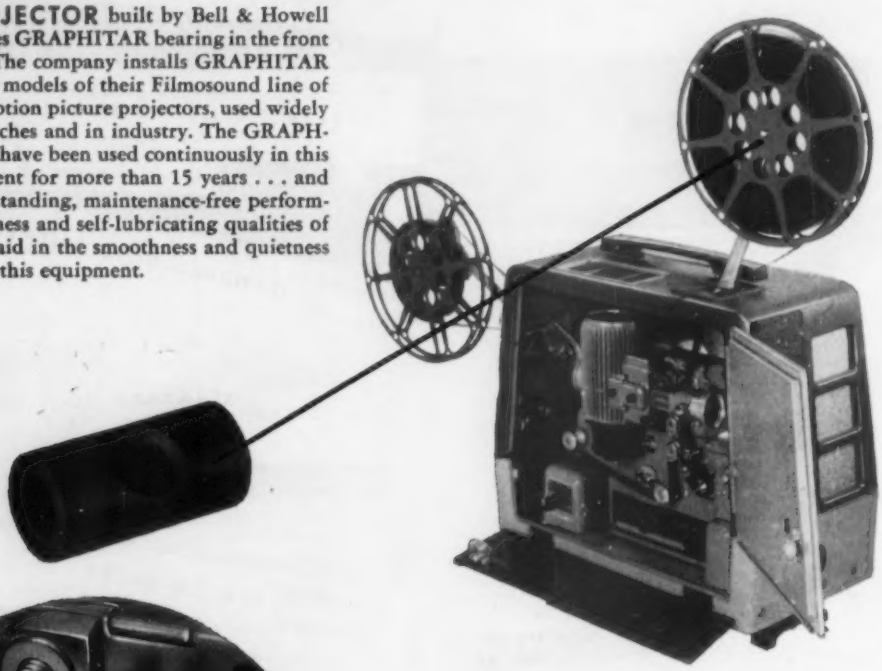
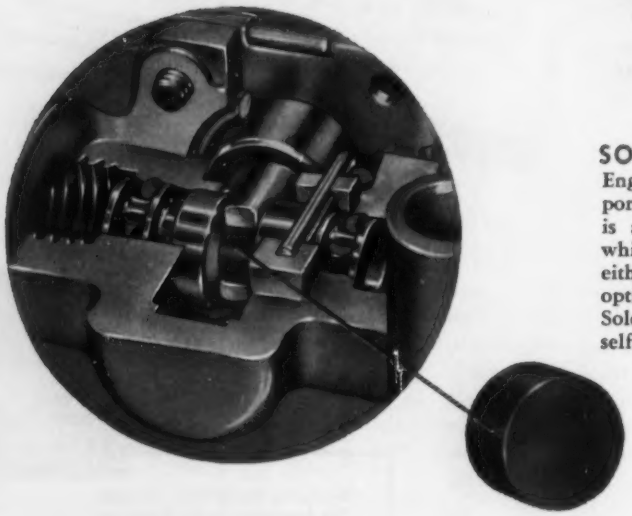
this is GRAPHITAR®

(CARBON-GRAPHITE)

successful in a wide variety of applications

MOVIE PROJECTOR built by Bell & Howell Company utilizes GRAPHITAR bearing in the front reel assembly. The company installs GRAPHITAR bearings in five models of their Filmosound line of 16mm sound motion picture projectors, used widely in schools, churches and in industry. The GRAPHITAR bearings have been used continuously in this line of equipment for more than 15 years . . . and have given outstanding, maintenance-free performance. The hardness and self-lubricating qualities of GRAPHITAR aid in the smoothness and quietness of operation in this equipment.

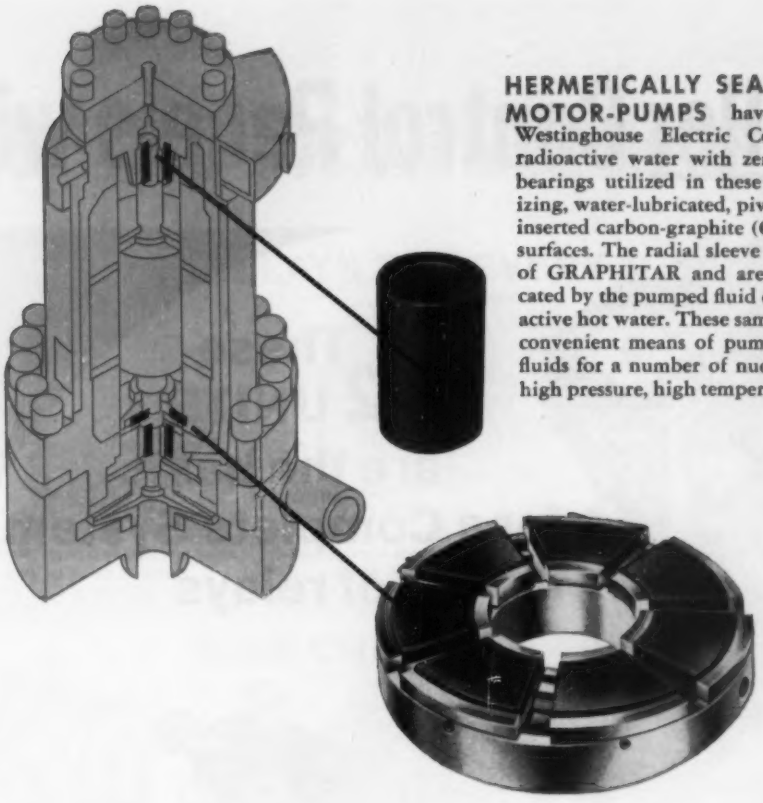




SOLENOID VALVES manufactured by Valcor Engineering Co. for use in guided missiles incorporate a floating seal of GRAPHITAR. This seal is a precise, optically flat GRAPHITAR disc which floats in the plunger. A slight pressure, from either direction, moves the disc against an equally optically flat, stainless steel seat, sealing perfectly. Solenoid valve improves with use due to unique self-lapping action of GRAPHITAR.

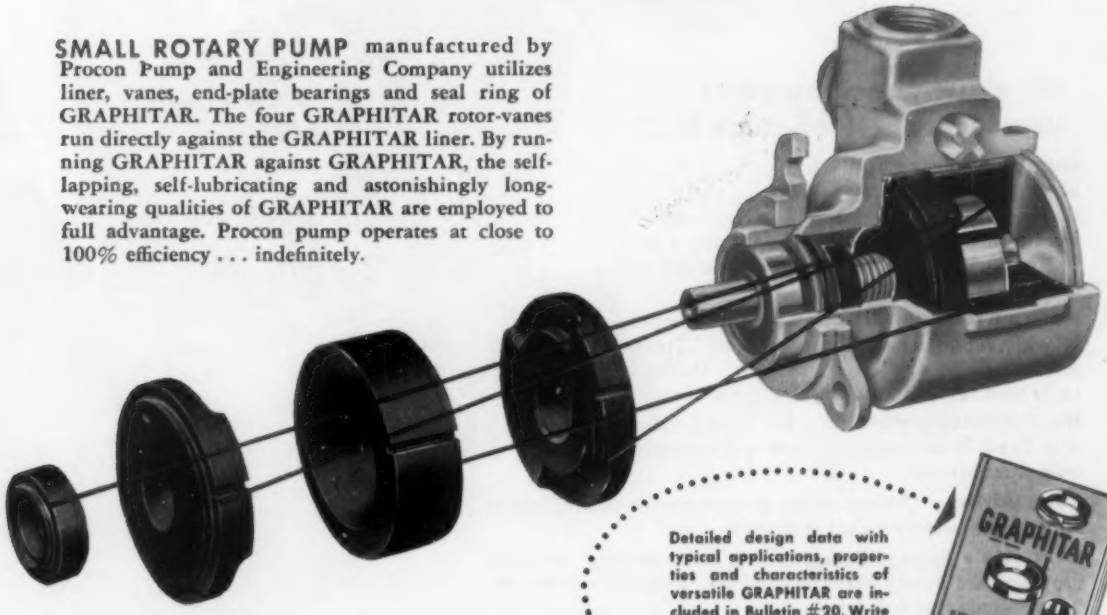
THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



HERMETICALLY SEALED MOTOR-PUMPS have been developed by Westinghouse Electric Corporation to handle radioactive water with zero leakage. The thrust bearings utilized in these pumps are self-equalizing, water-lubricated, pivoted-pad bearings with inserted carbon-graphite (GRAPHITAR) bearing surfaces. The radial sleeve bearings are also made of GRAPHITAR and are designed to be lubricated by the pumped fluid only, in this case, radioactive hot water. These same pumps have proven a convenient means of pumping high temperature fluids for a number of nuclear reactors and other high pressure, high temperature fluid applications.

SMALL ROTARY PUMP manufactured by Procon Pump and Engineering Company utilizes liner, vanes, end-plate bearings and seal ring of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against the GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR, the self-lapping, self-lubricating and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage. Procon pump operates at close to 100% efficiency . . . indefinitely.



Detailed design data with typical applications, properties and characteristics of versatile GRAPHITAR are included in Bulletin #20. Write for your free copy.

R-265-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 1, MICHIGAN

Smaller Control Panels with

CLASS 8501
TYPE DO-22

These 2 UNITS are the basis for a Complete System of relays

CLASS 9050
TYPE AO-1E

Here's why designers and users alike prefer Square D...

Complete selection • Relays available for both AC and DC systems—with up to 10 contacts—in both electrically and mechanically held forms. Timing relays with intervals from 0.2 second to 3.0 minutes—also in AC and DC versions.

Require less panel space • Relays are only 3" wide, range in height from 3¼" to 5". Timers are just 2⅜" x 4⅜" or 2½" x 7²½". Mechanically held relays require no extra panel space.

No mounting problems • All Type D relays and Type A timers have identical mounting hole dimensions.

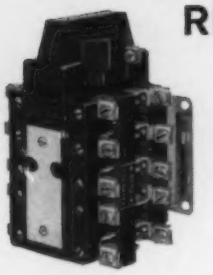
Easy wiring • Choose either pressure wire connectors or slip-on connectors for all terminals.

Long life • Balanced construction reduces wear on single moving part. Epoxy-resin molded coil operates cooler, virtually eliminates coil burnout.

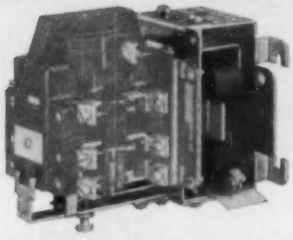
SQUARE D COMPANY

Square D "SYSTEM-DESIGNED" Relays

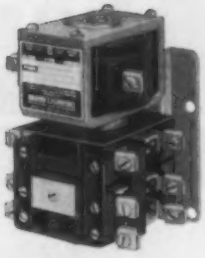
RELAYS FOR EVERY JOB



Square D Type D relays available with up to 10 contacts

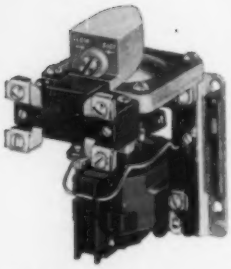


Easy-to-use attachment converts any Type D relay to mechanically held with no increase in panel space

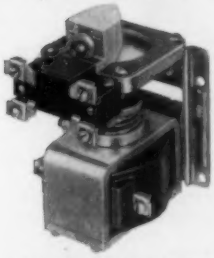


DC relays have mounting dimensions and contact arrangements identical to AC relays

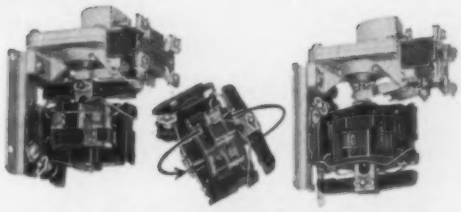
WIDE CHOICE OF TIMERS



Timing relays have same mounting dimensions as Type D relays

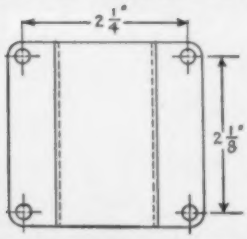


Matching DC timing relays

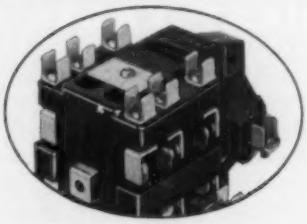


Both AC and DC versions convertible from on-delay to off-delay, using only a screwdriver

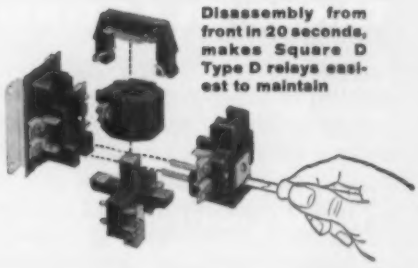
FAMILY FEATURES SIMPLIFY DESIGN PROBLEMS



Mounting dimensions are identical for Type A timers and Type D relays



Slip-on connectors for all terminals available



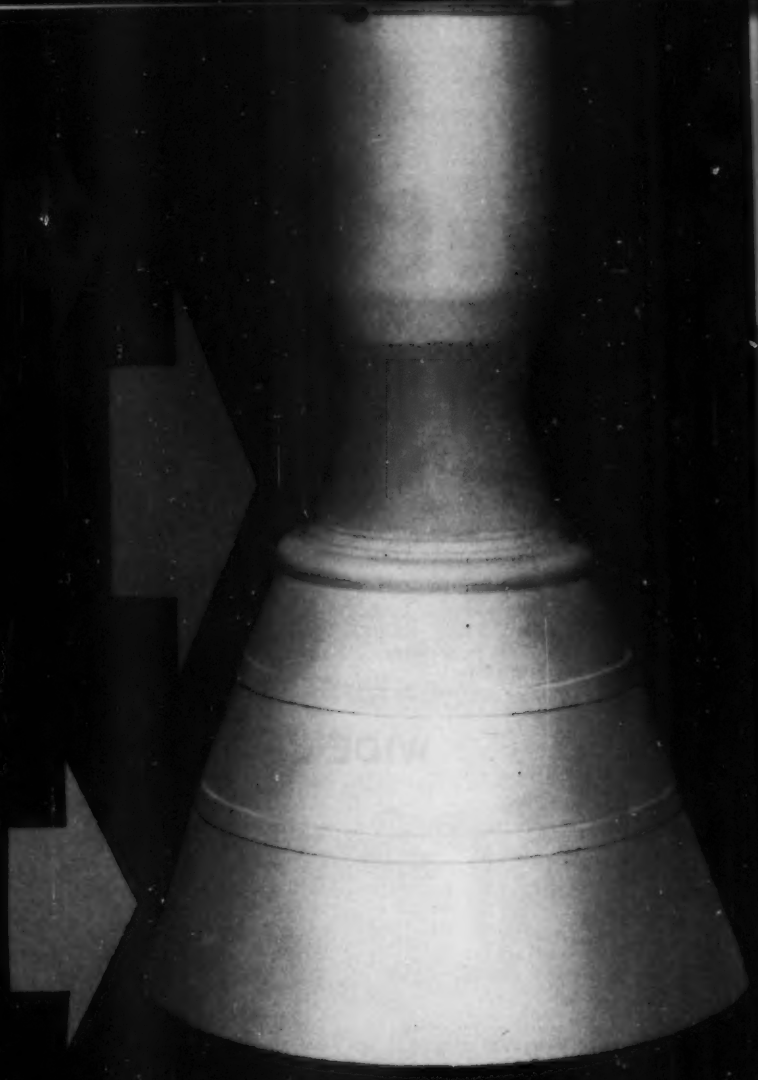
Disassembly from front in 20 seconds, makes Square D Type D relays easiest to maintain

Write for full details • *Ask for Bulletin D, Square D Company, 4041 N. Richards St., Milwaukee 12, Wis.*

Square D offers the broadest line of relays, starters and accessories for all types of control systems

Ask your Square D Field Engineer about the new ILO program

FLAME-PLATED WITH TUNGSTEN CARBIDE...



PIONEER'S THRUST CHAMBER TAKES BLASTING HEAT—LASTS 50% LONGER!

Aerojet General Corporation added 50% more operating life to Pioneer's second-stage thrust chamber with Linde's Flame-Plating process. Now, the lightweight aluminum tube, Flame-Plated with a thin (.003 in.) coat of tungsten carbide, has thermal and erosion resistance that stands up to the metal-killing temperatures of the combustion flame.

With this special Linde process, you can have metals coated with tungsten carbide, aluminum oxide, and other materials to provide outstanding resistance to wear, abrasion, and fretting corrosion, even at extreme temperatures. If necessary, these coatings can be ground and lapped to one micro-inch rms or better. They consistently outlast hard chrome plating, tool steels, and in some cases, solid tungsten carbide.

When coatings of refractory metals such as pure tungsten, tantalum, molybdenum, and other ultra-high-melting-point metals are desired, Linde Company offers its new "Plasmarc" Torch service. To find out how Flame-Plating or the "Plasmarc" Torch service can solve your critical temperature and wear problems, write Dept. PG-102 Linde Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y.

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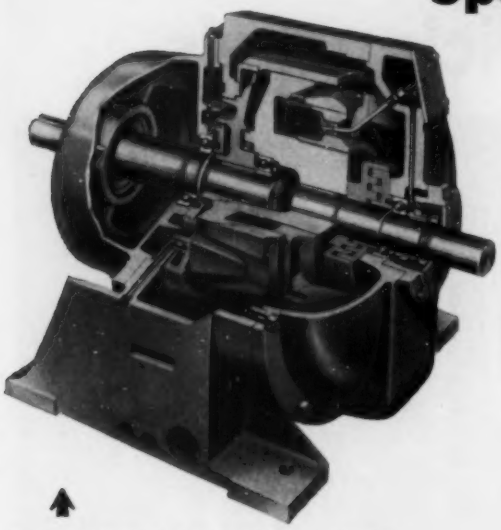
TRADE MARK

UNION CARBIDE

"Linde", "Union Carbide" and "Plasmarc" are trade-marks and F-L-P is a service mark of Union Carbide Corporation.

The BEST Solution to Difficult Speed Control Problems—

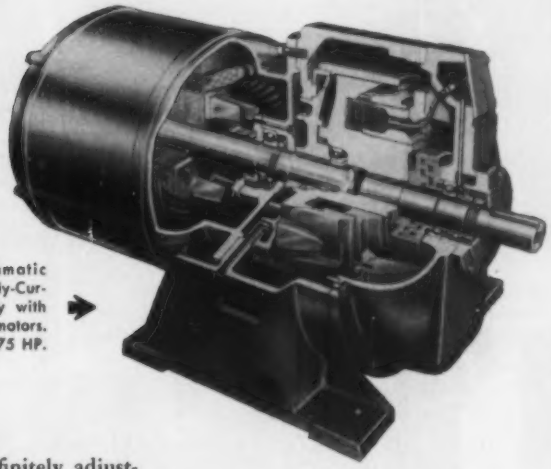


Dynamatic Liquid-Cooled Couplings provide infinitely adjustable speeds for nearly every application from 3 to 75 HP. Note the absence of slip rings, brushes, and commutators. Heavy-duty types with capacities up to 5,000 HP are also available.

EATON

DYNAMATIC®

LIQUID-COOLED EDDY-CURRENT COUPLINGS and DRIVES



"Dynaspede" Drives are Dynamatic Liquid-Cooled, Stationary-Field Eddy-Current Couplings mounted integrally with standard, D-flange, squirrel cage motors. Available in capacities from 3 to 75 HP.

Here's Why—

Dynamatic Liquid-Cooled Couplings and Drives provide infinitely adjustable speed from a constant speed source—or constant speed from a variable speed source. They operate on standard alternating current. Rotary power is transmitted through the coupling by an electromagnetic reaction between the driving and driven members of the unit—there is no mechanical contact of rotating members to cause wear and require adjustment or replacement.

A wide range of standard and special control features may be obtained from a remotely-mounted electronic control system. Infinite speed adjustment, constant speed control, on-off clutch control, torque limit, acceleration control, inching, and threading are a few of the many functions available. The addition of an eddy-current brake to standard couplings or drives provides smooth, cushioned stops and controlled deceleration.

Liquid-Cooled Dynamatic Couplings and Drives deliver more horsepower than other types of the same physical size, thus conserving space in a busy machine area. Efficient heat dissipation permits continued operation at low speeds, or stall with full load.

Completely enclosed, Dynamatic liquid-cooled units are protected from dust, dirt, and other atmospheric impurities. Dynamatic design involves no brushes or slip rings; there is no possibility of arcing. With simple modification these units can be made explosion-resistant for hazardous applications.

Infinitely Adjustable Speeds from AC Power

★

Full-Torque Starts

★

Wide Range of Control Functions

★

No Slip Rings, Brushes or Commutators

★

Completely Enclosed Design

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Low-Cost Maintenance

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DYNAMATIC DIVISION

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←CIRCLE 22 ON READER SERVICE CARD

CIRCLE 23 ON READER SERVICE CARD

EC-1357 cuts costs, makes possible stronger sandwich panels

LABORATORY TESTS show EC-1357 provides the high strength and rigidity called for in nonload-bearing sandwich structures.

3M Adhesive EC-1357 bonds all kinds of skin and core materials *without heat*. You'll speed production, cut costs, build in high strength for nonload-bearing sandwich panels.

You can force-dry the solvent out of the adhesive prior to bonding. And a nip roller or cold press is all that is required to complete the bond.

EC-1357 provides maximum immediate strength. And the bond continues to strengthen as it cures at room temperatures.

Dark in color, EC-1357 absorbs infrared heat quickly, dries fast; so no production delay is necessary. And it sprays on with minimum cobwebbing, thus saving materials.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

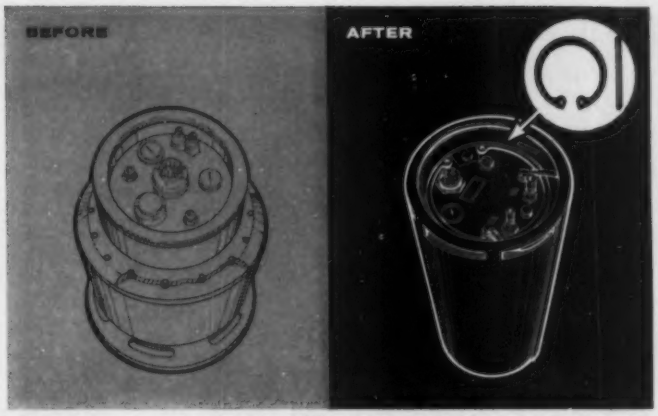
Consult 3M Research. Contact your 3M Field Engineer. Or, for information and free literature, write: A.C.&S. Division, 3M, Dept. YR-109, St. Paul 6, Minnesota.

ADHESIVES, COATINGS AND SEALERS DIVISION

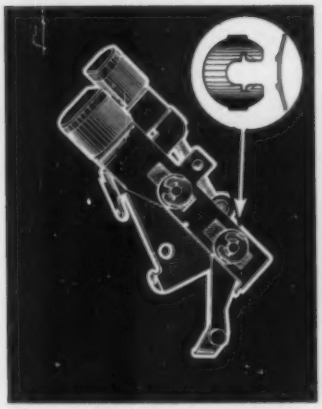
MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

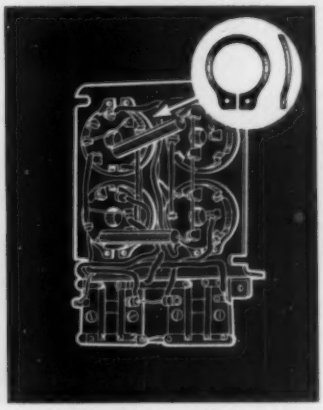
3M COMPANY



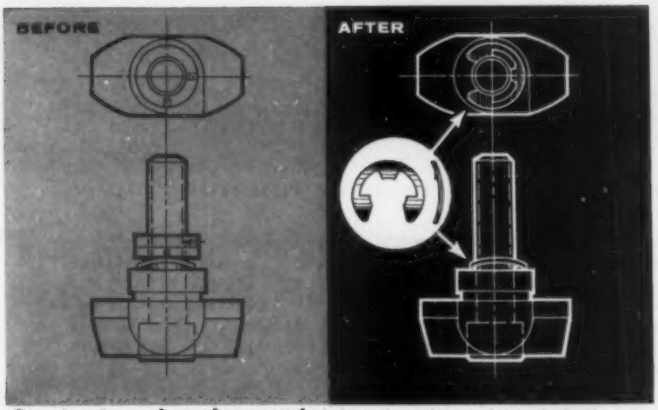
Pressure cover design simplified. Two axially assembled Truarc Series 5002 beveled rings eliminate 27 bolts, reduce machining and assembly time from 78 to 1½ hours and make possible drastic size and weight reductions. Rings retain two covers of a pressurized x-ray unit. **Savings: about $500 per unit.**



Parts eliminated in slide assembly. Two radially assembled Truarc Series 5139 Prong-Lock® Rings provide proper spring tension, eliminate looseness and wobble in this office calculator shift-slide. Original design called for a cut washer, spring washer, and cotter pin—all eliminated.



New way to install electron-tube sockets. Easy-to-apply Truarc Series 5101 bowed external rings lock tube sockets to chassis plate in this assembly. Bowed construction takes up tolerances of molded grooves, thickness of base. Individual sockets are removable for field service.



Quarter-turn clamp improved. A bowed washer and two locknuts were eliminated in this quarter-turn jig-and-fixture clamp by a Truarc Series 5131 bowed E-ring. The radially assembled ring holds the screw captive, provides required rotational drag between parts with sufficient tension to insure tight fit when the screw is first engaged. **Typical savings: $1.35/unit—assembly up 70%.**

Truarc rings for end-play take-up offer significant design advantages

A number of Truarc retaining rings are available to take up end-play or loose fit caused by accumulated tolerances and wear. The rings often eliminate spring washers, collars and set screws, nuts, bolts, rivets, cotter pins and other conventional fastening devices with outstanding cost savings in machining and assembly time.

Truarc retaining rings designed to deal with the end-play problem are of two general types: **bowed rings** for resilient end-play take-up and **beveled rings** for rigid end-play take-up.

Bowed retaining rings are widely used for preloading bearings, preventing vibration or oscillation in linkages, providing tension on adjusting screws. Of particular interest is the radially installed Truarc Prong-Lock® ring which locks securely to the shaft by means of two prongs. It provides exceptional thrust load capacity, may be used as a shoulder against rotating parts, and often eliminates springs, bowed washers and other tensioning devices.

In beveled rings for rigid end-play take-up, the groove-engaging edge is beveled at 15°. There is a corresponding bevel on the load-bearing groove wall. To take up end-play, the ring acts as a wedge between the outer groove wall and the part being retained.

These are just a few of the 50 functionally different types of Truarc retaining rings. They come in up to 97 standard sizes, six metal specifications, 13 different finishes. The entire line as well as accessory assembly tools, grooving tools, and over 70 typical applications are shown in the new catalog RR 10-58. Write for your copy today. And remember Waldes Truarc engineers are always ready to work with you on your specific projects. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N.Y.

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WALDES
TRUARC®
RETAINING RINGS
Waldes Kohinoor, Inc., Long Island City 1, N.Y.

TRUARC RETAINING RINGS...THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS

With Extras . . . At No Extra Cost

1. METAL PISTON ROD SCRAPER—protects rod packing, cylinder bore and rod surface by removing all foreign particles.
2. NEW "SUPER" CUSHION for air or METALLIC SELF-ALIGNING MASTER CUSHION for oil.
3. HARD CHROME PLATED CYLINDER BORES AND PISTON RODS for greater protection and reduced wear.
4. ONE PIECE PISTON assures better alignment, longer bearing and packing life.
5. FORGED SOLID STEEL HEADS throughout entire line.
6. PILOTED PACKING GLAND with extra long bearing for additional strength and support to piston rod.
7. NO TIE-RODS TO STRETCH—gives you 360° port rotation . . . less space used . . . full strength.
8. STREAMLINED DESIGN . . . operating pressures to 200 PSI, air; 1,000 PSI oil, non-shock.

Specify the

T-J Spacemaker

for longer, more efficient cylinder service

You too—can reduce replacement expenditures—lower maintenance costs with the T-J Spacemaker cylinder line. Designed and engineered for ruggedness, and accuracy of operation, the Spacemaker assures longer, uninterrupted operation.

The T-J Spacemaker eliminates tie-rods, gives greater strength, saves space . . . and reduces costs in all push-pull operations. Immediate delivery in a complete range of styles and capacities . . . air or oil. Write for Bulletin SM 155-4, today. The Tomkins-Johnson Company, Jackson, Michigan.

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RIVITORS · AIR AND HYDRAULIC CYLINDERS · CUTTERS · CLINCHORS

"To keep Whirlpool first line requires first line steels" —LESTER FIRST—DIRECTOR OF QUALITY CONTROL

"Quality control is important to Whirlpool, and to maintain the highest standards we must begin with quality materials," says Lester First, Director of Quality Control at Whirlpool's Clyde, Ohio plant.

"Through constant checking I find that Sharon is one of our suppliers we can rely on for consistently good steel right to our specs," Mr. First continues.

Leading appliance makers, like Whirlpool, know there's no substitute for quality steel. For quality steel there's nothing finer than that produced in the mills of the *Sharon Steel Corporation, Sharon, Pa.*

SHARONSTEEL **SHARON** *Quality* **STEEL**

CIRCLE 27 ON READER SERVICE CARD

No Other PROTECTOR but KLIXON Type T* Gives Your Product GREATER RELIABILITY

GREATER . . .

- ***Assurance Against Motor Failure***
- ***Reduction in Repairs and Service***
- ***Customer Satisfaction and Goodwill***

KLIXON and only KLIXON Type T Protectors completely safeguard motors against all possible conditions that cause motor burnouts.

Most conventional protectors used today provide only limited motor protection . . . against two, three or four overheat conditions. But KLIXON Type T Protectors safeguard motors from all six causes of motor burnout.

1. Running overload with or without high ambient or ventilation blocked.
2. Locked rotor normal voltage such as caused by mechanical failure or driven load.
3. Locked rotor caused by low voltage where decreased torque is insufficient to start load.
4. Locked rotor with main winding only in circuit resulting from open circuit start switch or open circuit in reversing switch.
5. Locked rotor with start winding only in circuit, such as that resulting from an open main winding circuit or open circuit in reversing switch.
6. Running with both start and main windings in the circuit resulting from start switch failure in closed position or low voltage which prevents reaching switchover speed.

Protect your motor-driven equipment completely against motor burnouts . . . specify on your purchase orders — "These Motors to have KLIXON Type T Protectors."

**Ask your motor manufacturer about it.*

Over 150,000,000 motors are protected against overheating and burning out with KLIXON *Protectors.*

METALS & CONTROLS

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A DIVISION OF TEXAS INSTRUMENTS INCORPORATED

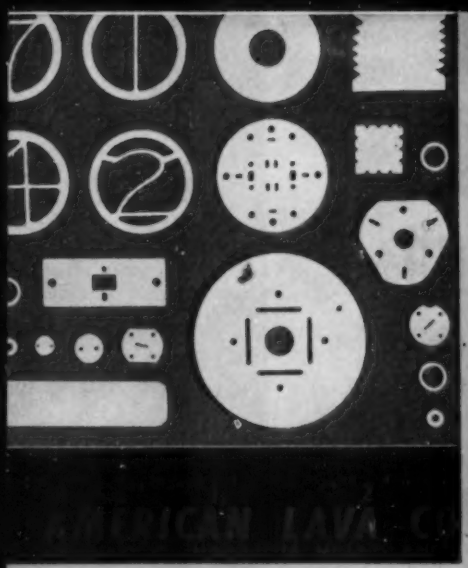
SPENCER PRODUCTS: Klixon® Inherent Overheat Motor Protectors • Motor Starting Relays • Thermostats • Precision Switches • Circuit Breakers

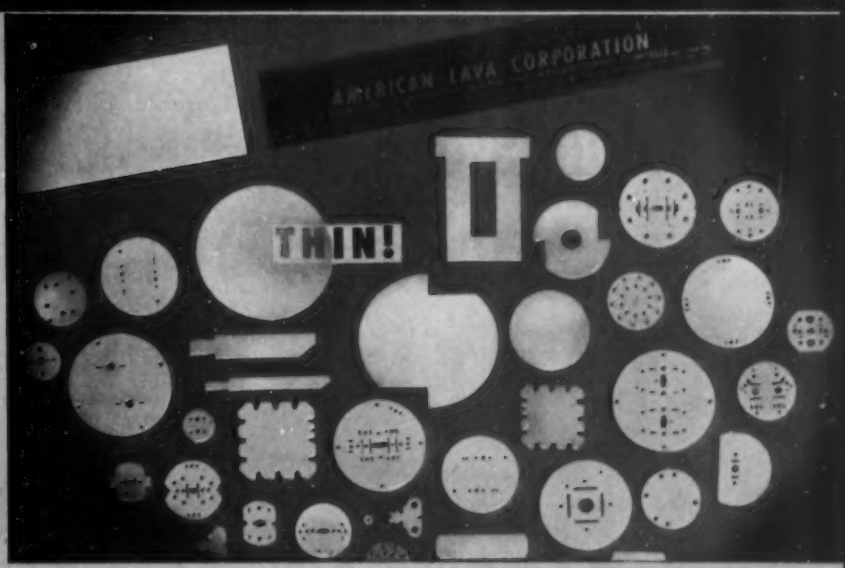
CIRCLE 28 ON READER SERVICE CARD

CIRCLE 29 ON READER SERVICE CARD→

NEW AlSiMag® THIN CERAMICS!

will these alumina ceramics give you SMALLER, LIGHTER, MORE RUGGED UNITS?





Miniature AlSiMag Alumina Ceramics—some as thin as 0.005"—are being used in electron tubes, microwave windows, transistor platforms . . . as insulators in hearings aids . . . in digital counter tubes, radio crystal cages . . . in high temperature transformers, relays, fuses, micro-modules . . . high temperature amplifiers . . . and other high temperature devices including high temperature printed circuitry . . . as well as various mechanical applications.

The relatively high strength of these thin ceramics and their superior performance in high temperature, high frequency applications may help you answer the demands for smaller, lighter, more rugged units. This strength also sharply reduces damage from fatigue failure, heat deterioration, shock and vibration, and makes new automatic assembly operations practical.

Since these thin ceramics were pioneered by American Lava several years ago, demand has increased rapidly and steadily. Spurred by constantly increasing requirements, our production facilities are now capable of shipping in volume and at practical prices, small intricate shapes that were considered impossible as recently as 1955.

Free bulletin and typical samples of thin AlSiMag Ceramics sent on request

A Subsidiary of Minnesota Mining and Manufacturing Company

AMERICAN LAVA CORPORATION

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58TH YEAR OF CERAMIC LEADERSHIP

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NOW...

Robbins & Myers Calculates a New Motor Design EVERY 1 to 6 MINUTES!

R&M Engineers Explore Hundreds of Design Combinations to Achieve OPTIMUM MOTOR PERFORMANCE!

How many ways *could* a motor be designed — a polyphase motor, for example? At least 27 basic variables offer 27^{27} (30 zeros) possibilities! Theory, of course, but still there's a colossal number even after obviously impractical designs are ignored. Working with slide rule, an engineer can calculate maybe four designs per day . . . and that's the time-consuming way it was done once. But now ROBBINS & MYERS engineers can explore hundreds of design possibilities, using their Data Processing System. With infallible accuracy, IBM's 20,000 digit "Magnetic Memory" is able to calculate a new motor design every one to six minutes! Because R&M engineers can now explore hundreds of design combinations before they make a final decision, you get the one motor that will deliver optimum on-the-job performance! And at no extra cost!

"Mechanized" mathematics at ROBBINS & MYERS also gives engineers more time for design *vision* and *decision*, which no machine can possibly provide . . . and enables them to improve existing motors by probing alternate design possibilities.

If you are ordering integral or fractional HP motors, or series motor parts, remember this fact: *the greater the number of practical design possibilities the manufacturer explores before the motor is produced, the better the motor will perform!* When your motor comes off the assembly line at ROBBINS & MYERS, you can be certain you are getting the best design possible, perfectly adapted to your requirements, and quality-built to perform dependably for years to come!

ROBBINS & MYERS, INC.

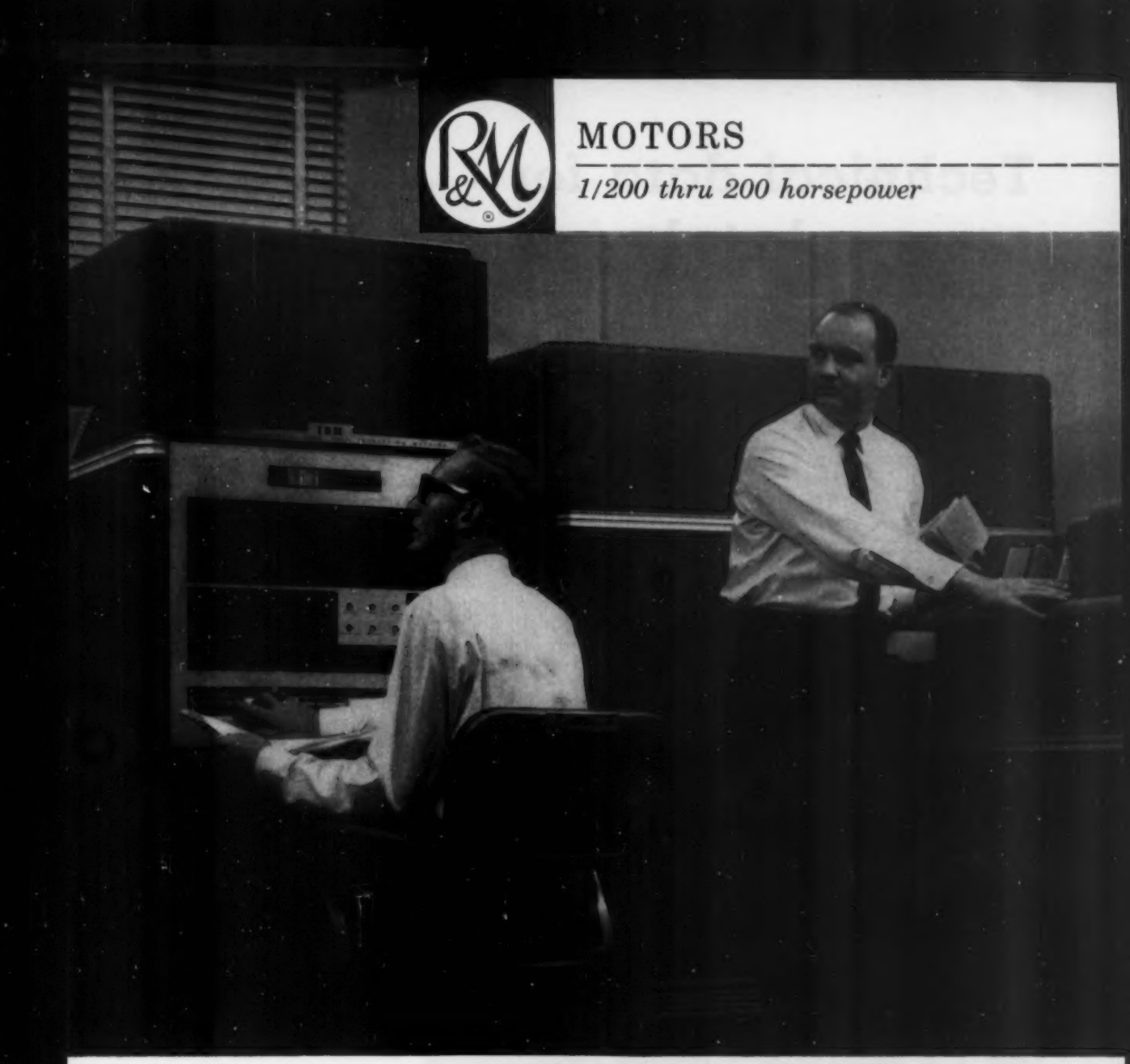
motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

CIRCLE 30 ON READER SERVICE CARD

MOTORS

1/200 thru 200 horsepower



Design answers in seconds from IBM 20,000 digit magnetic memory!

Integral Motors (left), range from 1 to 200 HP in single-phase, direct current, polyphase, totally-enclosed fan-cooled, and explosion-proof types.

Standard Fractional HP Motors (right), are available in polyphase induction, capacitor start, resistance split-phase, and permanent split capacitor, in open and totally-enclosed types.

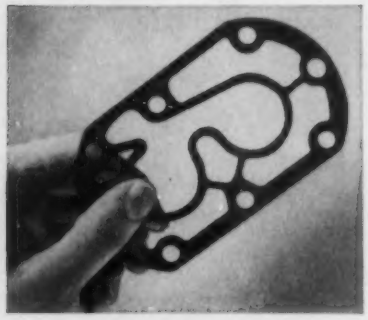
Precision-Made Universal Motors and Series Motor Parts (left), enable manufacturers of electric power-driven equipment to make the motor an integral part of their product.

Business Machine and Commercial Appliance Motors (right), are available in standard or custom designs.

Technical data for gasket design and selection

Choosing a gasket for compressors

In selecting a gasket material for a compressor head, the first consideration is the gasket's ability to withstand the usual ambient temperature of about 300° F.



At such elevated temperatures, and with internal pressures ranging well over 100 psi, torque retention becomes another critical factor.

In the case of refrigerator compressors, the choice of a gasket is further limited by the presence of refrigerant gases which attack many gasket materials.

A material that meets these requirements is Accopac AN-890, a new beater-saturated gasket material pioneered by Armstrong. Accopac AN-890 is a blend of refined asbestos fibers with a nitrile-type rubber binder.

AN-890 withstands temperatures up to 800° F. Its nitrile-type rubber binder swells slightly in the presence of refrigerant gases. Since these gases do not deteriorate AN-890, the swelling acts to maintain a tight seal.

Bolt torque retention of Accopac AN-890 has been proved by comparing a flange containing refrigerant gas at 350° F. and 150 psi, and a control flange at room temperature and no gas. Accopac maintained bolt torque equally well in both flanges.

Because of the thorough refining of the asbestos fibers, AN-890 die-cuts cleanly. It also costs less than conventional asbestos materials.

For more information, write for a copy of our new folder, IND-915.

How heat affects the selection of resilient gasket materials

In selecting a resilient gasket material for use where the temperature at the gasket line will be substantially higher than room temperature, the various effects of heat must be considered.

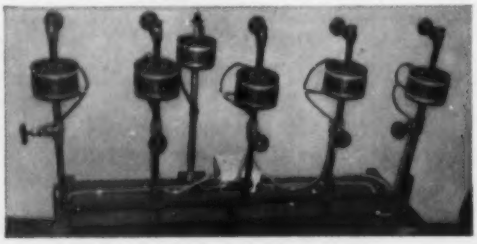
In many cases, heat is less of a limiting factor than is commonly supposed. If a designer knows the range of temperature limits of the various classes of resilient gasket materials (see table), he may find that a resilient material offers service equal to a more expensive gasket.

A more subtle effect of heat—and one more difficult to detect—is the softening it tends to produce in almost any non-metallic gasket.

Generally, this is manifested by things variously known as torque loss, stress relaxation, and creep. Because of plastic flow or some form of fatigue, high temperatures tend to reduce the ability of a resilient gasket to maintain flange pressures over relatively long periods.

Loss of bolt torque induced by heat can be minimized by selecting a gasket material with good torque retention properties. The Armstrong Accopac line includes several such materials. Generally, the denser the gasket the better its torque-retention properties, (see table). In addition, where heat is involved, it is all the more important that initial bolt loads be adequate.

A more complete discussion of the effects of heat on resilient materials is contained in the new Armstrong Gasket Design Manual. Write for your copy today.



This apparatus—called the "hot spider"—permits simultaneous testing of gasket materials at temperatures up to 750° F. and internal pressures up to 500 psi under varying conditions of flange loading.

Class of material	Maximum sustained temperature at gasket line*	Rank in order of torque retention
Asbestos	750° F.	1
Cellulose	300° F.	2
Cork-and-rubber	250° F.	3
Straight rubber	250° F.	4
Cork composition	250° F.	5

*These are recommended design limits. Obviously, in many applications temporary exposure to higher temperatures can be tolerated. Consideration should also be given to nature of contained fluids, since some fluids which are inert at room temperature become more active as temperatures increase.

Resilient gaskets usually are organic, and exposure to high temperatures can cause physical damage such as charring. If charring does occur, the damage will, of course, be obvious and leaks will result. This can generally be avoided by staying within recommended limits of the material or by using an inorganic gasket such as Armstrong asbestos Accopac.

Send for a copy of the new Gasket Design Manual, IND-763, containing 34 pages of valuable information for engineers. Armstrong Cork Co., 7010 Irvin Street, Lancaster, Penna.

Armstrong GASKET MATERIALS

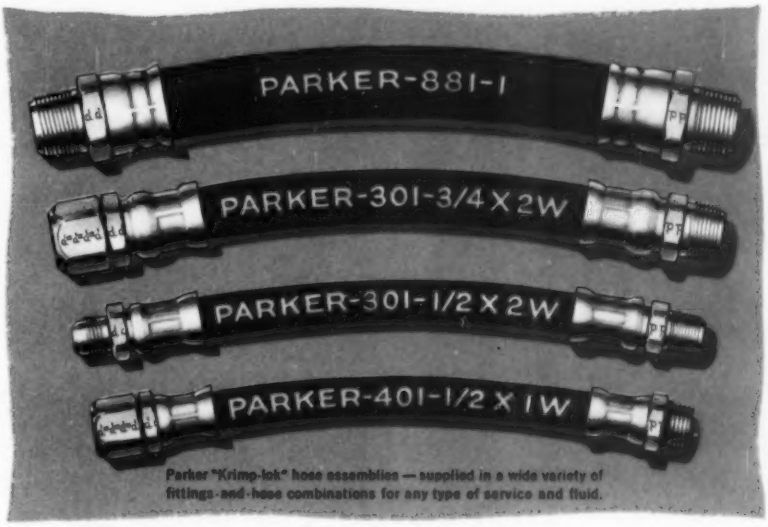
. . . used wherever performance counts

CIRCLE NO. 33 FOR FITTINGS, NO. 34 FOR CYLINDERS

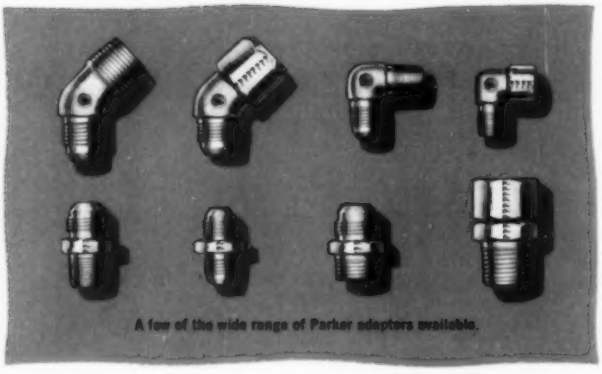
PARKER-HANNIFIN FLUID-SYSTEM COMPONENTS

Now from Parker

BOTH permanent-end and re-usable hose assemblies



Parker "Krimp-lok" hose assemblies — supplied in a wide variety of fittings-and-hose combinations for any type of service and fluid.


A few of the wide range of Parker adapters available.

You may require permanent-end hose assemblies for your production AND re-usable fittings with coils of hose for quick, trouble-proof replacements in the field. With the addition of Parker's new "Krimp-lok" fittings, permanent-end assemblies are now available from Parker. They use the same Parker hoses that enjoy a wide acceptance when used with Parker *no-skive* "Hoze-lok" fittings in the replacement field.

A full range of Parker adapters is also available.

Ask your Parker Hose Distributor, listed in the Yellow Pages, for engineering advice and literature on "Hoze-lok" re-usable fittings, also Parker hose and adapters. Write us in Cleveland regarding your requirements for Parker "Krimp-lok" Hose Assemblies.

Parker

FITTINGS AND HOSE DIVISION

17325 Euclid Avenue

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Parker "Hoze-lok" no-skive hose fittings and Parker hose, the ideal combination for short-run production and quick, reliable field replacement.

A DIVISION OF PARKER-HANNIFIN CORPORATION

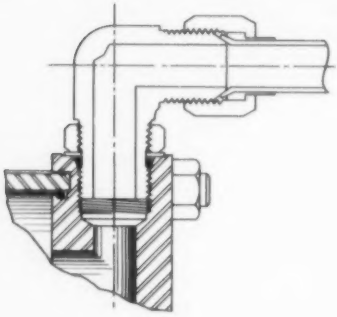
Bronze cartridge gland with "LIPSEAL"® and "WIPERSEAL" can be easily replaced without dismantling cylinder.

Drip-free rods, leak-proof ports...

get both with

HANNIFIN

hydraulic cylinders



Specify straight thread O-ring bosses on your Hannifin high-pressure hydraulic cylinders for leak-proof connections at no extra charge. These port connections, together with Hannifin's drip-free rod seals, provide the answer to all your cylinder sealing problems.

Select either "Step Seal" piston rings (standard) for most applications or exclusive "LIPSEALS" where zero "clearance flow" is required.

For absolutely leak-proof connections under all operating and installation conditions, get Hannifin hydraulic cylinders with S.A.E. straight-thread ports. There's no extra cost. And because a straight-thread fitting is tightened *after* alignment, not aligned by "backing off," sealing is positive even when the cylinder must be mounted in tight quarters.

Straight-thread ports, plus the removable-replaceable cartridge gland that seals Hannifin cylinder rods drip-free, keep machines, floor and product free of hydraulic oil.

Other Hannifin cylinder features include ground and polished rods induction-hardened to an extra-deep case, then hard-chrome plated and polished again; cylinder walls that are "Tru-Bored" straight and perfectly round *before* being honed . . . PLUS 48-hour shipment in emergencies on standard Hannifin cylinders.

Your nearest Hannifin sales office or representative is listed in the A-Z volume of Thomas' Register. Call us in when cylinders figure in your designs. Or, for cylinder literature, write:

HANNIFIN COMPANY

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DEVELOPMENTS TO WATCH...

New safety devices are needed . . .

. . . for home appliances as well as machine tools, safety experts say.

Accident figures are showing an "ominous increase." In the past two years, for instance, doctors at just one hospital in Washington, DC were called on to treat 120 cases of hand and arm injuries caused by washing machine wringers.

In the machine-tool field, the situation is equally alarming. Most equipment builders now offer machines with cutting tool guards and enclosed gears and shafts. But, says T. H. Rockwell of Ohio State U, such machines often defeat their own purpose by so hindering the job that the most productive worker is the one who most effectively circumvents them.

The cost of guarded machines is also a problem. As J. A. Dickinson of National Bureau of Standards points out in a paper prepared for the forthcoming meeting of the National Safety Congress (Oct 22 in Chicago) many small plants buy unguarded equipment because it is cheaper. They plan to add their own safeguards—but too often forget to do so until it's too late.

Designing better safety equipment is not an easy job, either. As Rockwell points out, there is no adequate measurement of the effectiveness of machine safeguard; no quantitative system for defining adequate safety performance; and no accurate way to evaluate the effectiveness of control techniques. But he does believe that such measurements can be developed and suggests methods for doing so.

Choice of base metal is key to adhesive performance . . .

. . . in design of metal structures for elevated temperature service, Forest Products Laboratory researchers find. Effectiveness of metal-bonding adhesives depends as much on the nature of the base metal as on the adhesive itself, they say.

At 550 to 600 F, for instance, polyamide, epoxy, and polybutadiene-acrylonitrile compounds show considerably better resistance to thermal degradation when applied to aluminum than they do on stainless steel. Phenol-nitrile rubber adhesives, on the other hand, do much better on stainless than on aluminum.

Surprisingly, combining resins may completely reverse their performance. A mixture of polyamide and epoxy resins shows high thermal resistance when applied to stainless steel at 550 F, and considerably lower performance levels in aluminum bonds.

Work is continuing, aimed at further exploration of correlations between polymer structure, temperature, and the nature of the metal surface. But a report has been prepared on the first phase of the work and is being made available by NASA.

Note: FPL is also evaluating low-temperature performance of metal-bonding adhesives—in this case, for NBS.

Only preliminary tests have been made; but indications are that best results will be obtained when thermal expansion of the adhesive is matched to that of the adhered. This can be done by using metal dust as a filler.

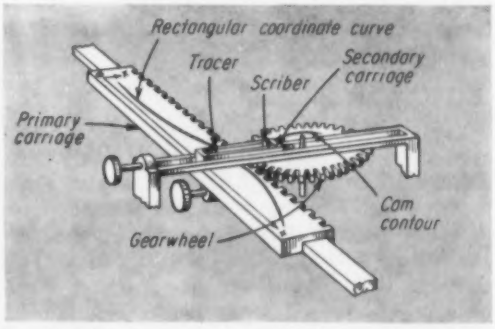
Of 10 adhesives so far tested on lap joints at temperatures to —424 F, metal-filled, glass-supported epoxy-phenolic resins give highest shear strength.

An instrument for laying out cams . . .

. . . has been developed by Soviet engineers. It's a dual-rack tracing-and-scribing device (see diagram) which converts the rectangular coordinates of a cam into a circular scribed line defining the cam's actual contour.

The Soviet technical journal *Isobretatel i Ratsionalizator*, describes the operation of the contour-generating device this way:

The rectangular coordinate curve is attached to the primary carriage of the machine. Following the curve visually, the handwheels that control the primary and secondary carriages are simultaneously rotated, moving the two carriages. As this is done, the curve is converted into a cam contour which appears in the form of a scribed outline traced on the upper surface of the gearwheel on the secondary carriage.



Cam-developer consists of rack and gearwheel system, controlled by and through movable carriages. Rectangular coordinate curve is attached to primary carriage; and cam shape is developed on gearwheel by scriber.

DEVELOPMENTS TO WATCH...

Lubricant wetting agents may sap the strength . . .

. . . of metals to which they are applied, recent chemical research indicates. This can happen, as a matter of fact, not only with lubricants but with any fluids in which surface-active agents are used. Researchers at the Columbia Univ School of Mines find, for instance, that "the addition of oleic acid to the surface of copper wires effects a five-fold decrease in rupture time at high-load and a two- to three-fold increase in initial creep rate."

Many explanations for those effects are being advanced. Among them:

1. Chemical interaction between the natural oxide layer on the surface of the metal and the surface-active (wetting) agent or its supporting medium.
2. Restriction of oxygen access to the metal surface, by the agent or its medium, inhibiting formation of the protective oxide.
3. Interaction between the agent and the oxide layer, altering the oxide structure.
4. Removal of the oxide layer by a detergent ("cleaning") process involving displacement of the oxide by the surface active agent.
5. Catalytic action of the metal on the surface-active agent, producing new compounds which may affect the oxide.

Research at Columbia has confirmed the first two, and does not rule out the others. Indeed, there are indications that the effects are considerably more far-reaching than originally supposed. They may have been overlooked in the past, though, because as L. Nanis and J. H. Schulman of Columbia point out, an aging period of about 20 min. between application of the surface-active agent and initiation of the test is necessary to observe the effect.

New designs in magnetic shaft seals . . .

. . . will permit their use with nonlubricating as well as lubricating fluids at high pressures, A. W. Lighter of A W Chesterton Co predicts.

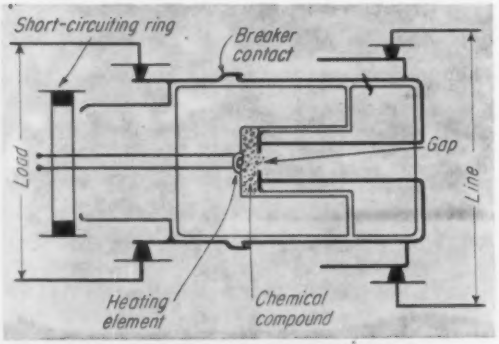
Until now, use of this type of mechanical seal has been limited by excessive wear on the carbon section of the rotating component. But, says Lighter, "tests are currently being conducted in an effort to overcome this problem, and initial results indicate that the problem can be solved." Several approaches are being tried but, Chesterton engineers emphasize, much development work remains to be done.

Another difficulty which hampered industrial applications for magnetic seals—corrosion of the magnet—has now largely been solved, however, the company reports. A heavy rhodium plate will "render the magnet virtually impervious to attack by corrosives" and also provides a good working surface. Plated magnets are now in service, and performing well.

Circuit breakers with response times of less than one millisec . . .

. . . are being developed at Ferraris Electrotechnical Institute, Turin, Italy taking advantage of the fact that some chemical substances dissociate very rapidly into electrically charged gaseous particles when heated. This changes them from nonconducting to conducting materials and permits a current to flow that will activate a safety circuit.

By proper selection of materials (so far, compounds of the general formula $R_n(NO_2)_m$ seem best), cutoff times as fast as 0.0001 sec have been achieved. Compounds of this type, to which small amounts of organic salts (alkali halides, for example) are added, change from solid to ionized gas at high speed. Furthermore, they will produce a large volume of gas, building up a pressure high enough (about 15,000 psi) to cause a mechanical deformation that will open one circuit and close another. Service tests indicate the device can be used safely, even in flammable atmospheres at high loads. —ARG



Ionized gas circuit breaker of the double-pole type is illustrated here. Short-circuit voltage, applied at terminals, generates heat in coil and triggers reaction in the chemical substance. As the main current flashes across gap, the chemical reaction accelerates, building up vapor pressure until the line is opened and the load short-circuited.

Building-block Concept Highlights European Tool Show

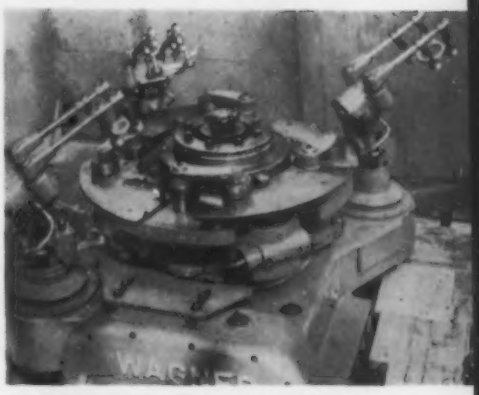
PARIS—Automatic machines, many of them designed to function as self-contained units in flexible automatic production lines, highlighted the Sixth European Machine Tool Show at CNIT (Centre National des Industries et des Techniques) Exposition Palace on the outskirts of Paris.

Chute loaders, chain loaders, rotary loaders and gripper arms turned up among the variety of automatic loading and unloading devices fitted to multipurpose machines with automatic machining cycles. Linked together by conveyors, these automatic machines made for automation with a European touch. Production is automatic; parts are passed from machine to machine as they evolve from stock into a finished component. But the linked lines, like the machines, are flexible in purpose. They can be changed over readily to produce different components, making automatic production economical for European-size runs.

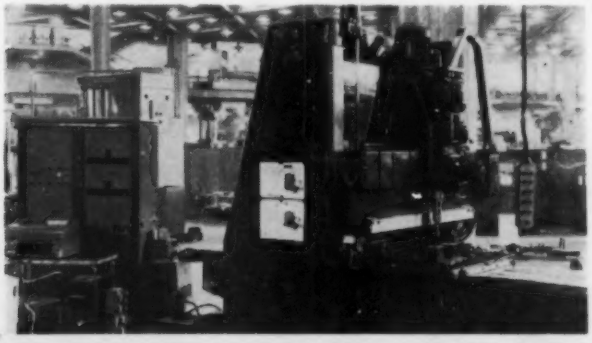
Representative of this approach to automation was the automatic ring-rolling plant shown by Wagner & Co of Dortmund, Germany. Here, an automatic transfer device passes heated billets from an induction furnace, itself fed by a vibrating conveyor, through three stations on a forging press and on to the rolling mill. Tongs on the mill transfer the workpieces from station to station and then drop the finished component into a chute. Rings up to 2 lb can be produced at a maximum rate of 450 an hour.

FEW NUMERICAL CONTROLS

Many manufacturers had machines with electronic controls on their display stands, but there were relatively few with numerical control. G.S.P. of France, with its universal machine, pulled large crowds. The machine can be programmed with punched 35 mm



Automatic tongs manipulate blanks through Wagner ring-rolling mill. One set takes blanks from forging press to rough-rolling mandrel; second set transfers blanks to finish-rolling mandrel; third set transports blanks to output chute for next operation.



Magnetic tapes operate GSP universal machine, (left), Hayes/Ferranti vertical milling machine (above), and Wadkins gantry drill, (above left). On the GSP machine, X, Y, and Z positioning coordinates can be manually established and speeds and feeds selected. Progress of the cycle in each of the three coordinates is indicated on console. Wadkins handles single jobs by dial setting. Ferranti claims the magnetic-tape control, in a small manufacturing operation producing 5 to 20 parts, cuts machining time by 7/8 and production costs 29%.

film for large runs or, by means of its control console, set up for automatic three-dimensional positioning from preselected coordinates. British manufacturer Ferranti showed a Hayes vertical milling machine controlled by a magnetic tape. Another British manufacturer, EMI, came up with an electronic control designed for the small user; a drill equipped with the control markets for about $4500. Either punched tape or knob settings can be used to establish the program. A larger EMI control masterminded the movements of a Wadkin gantry drill. The drill can hold very tight tolerances on holes up to 2-in. dia, and pilot holes are not necessary.

PHOTOELECTRIC SYSTEMS

Photoelectric positioning systems also turned up at the show. On German manufacturer Froriep's horizontal borer, the control positions the spindle in the horizontal and vertical directions with an accuracy of 0.0004 in. SIP, of Switzerland, presented a jig boring and milling machine with automatic "repeat" of spindle-head and table settings. In this system, the operator sets up the coordinate positions by means of direct-reading scales. Magnetic memory drums in a transistorized control unit store the settings for subsequent automatic repositioning. The positioning system reads the scales on the machine photoelectrically and compares them with the stored information. In this way, SIP says, accuracy of about 0.0004 in. is obtained for the automatic repetitions.

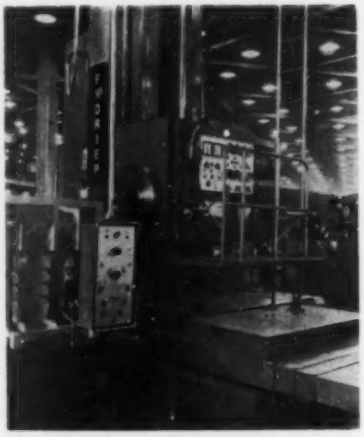
PROGRAMMERS

Plug-board programmers were very much in evidence at the show and ranged widely in complexity. One of the simplest turned up on British manufacturer Herbert's capstan lathe. The plug-board on this unit automatically changes spindle speeds each time the turret is indexed manually. At the other extreme were the Electropilot programmers of Max Muller, a German manufacturer. A typical unit handles up to 20 instructions per stage up to a total of 30 working stages, capacity enough to control completely spindle speeds, tool feeds, turret indexing and loading devices for intricate machine cycles. A variation on the plug-board appears in the Pittler Piromat 23 lathe. In this German-built equipment, electrical connectors combine with the plug-board to establish the cycle.

One feature common to most of the plug-board programmed equipment at the show was provision for fast changeover of machining cycles. Prepunched cardboard templates make resetting the plugs a matter of a few minutes. The dogs that trip limit switches to control tool movements on the machines themselves can in many cases be set up in advance on spare dog plates. With templets and preset dog plates, changes from one complex cycle to another can be made in 45 minutes or so.

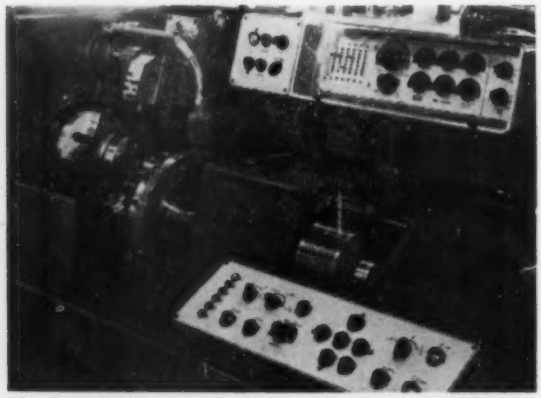
SPECIAL MACHINES

Although standard multipurpose machines dominated, a variety of special-purpose units were available. Outstanding was the Heyligenstaedt (German) twin copy-turning machine that turns both sides of thin-wall disks simultaneously. —Arthur Erikson



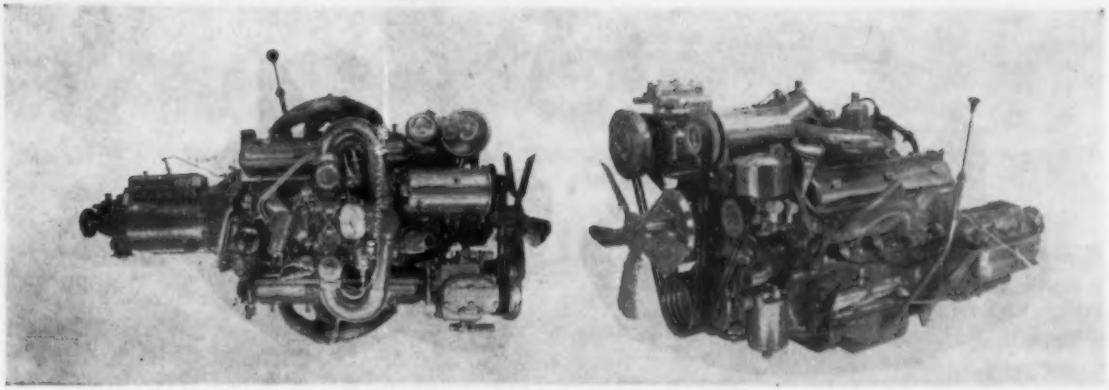
Photoelectric coordinate positioning system establishes horizontal and vertical settings of spindle head in the Froriep borer. Light source shines through special glass scales onto slit of photocells. Scale divisions interrupt light beam to generate series of impulses that signal amount of movement required to reach preset position. Eight dials on machine head, four for each coordinate, select preset position.

Special purpose unit turns both sides of a large-diameter, thin disk—cutting machining time 70% when compared with one-side operation. Two copying slides with templets and controls permit machining of asymmetrical contours. Tolerance on a 30-in. disk, 0.04 in. thick, is 0.001 in.



Plug-board selects one of eight possible spindle speeds for each of six automatically indexed turret positions on Pittler lathe. Dial settings establish feed rate. Sequence of movements for the turret and slide is set by interconnecting contacts on electrical plug in electro-hydraulic control system.

Rolls-Royce Introduces New Engine



A new 6.23-liter, V-8 cylinder engine for Rolls-Royce is equipped with an all-aluminum cylinder head and block, an over-square bore-stroke ratio of 104.4 mm x 91.44 mm, and a modest compression ratio of 8:1. The newcomer replaces the existing 6-cylinder inline engine of 4.8 liter capacity. Horsepower per liter rating is a modest 35/40 bhp per liter, giving an output in the region of 240 bhp. Use of a light alloy along with compactness of cylinder arrangement affords a 30% increase in capacity, with no increase in weight. A grease lubrication system, preloaded for permanency requires reloading only after every 10,000 mi. Basic cost is increased 8% to $14,895 in US. At left is overhead view of new engine. At right is oblique view.

Mass-produced Russian Tools Threat to West

PARIS—Russia is mass-producing basic types of machine tools at costs that Western European manufacturers cannot match, according to Seymour Melman, Columbia University professor who surveyed Western Europe's machine tool industry for the European Productivity Agency (EPA).

In a swing through major Russian machine-tool plants, Melman found productivity three to four times higher than that in Western European plants turning out comparable products. Lathes are coming off the production line in one Russian plant at a rate of one every 15 minutes, Melman says. Labor requirement for each lathe is 200 manhours, compared with 650-800 manhours for similar lathes produced in Western Europe.

Russia is also way ahead of the West in standardizing machine-tool parts, Melman points out, and is putting vigorous efforts into using "building-block" components wherever possible. And the way the cards are stacked now, the Soviets will probably widen the gap. At the ENIMS machine tool institute in Moscow, 1000 researchers are at work, many of them investigating methods of applying mass-production techniques to machine-tool building. The largest comparable institute at Aachen, Germany, has only 100 people.

A big factor favoring mass production of machine tools in Russia is concentration of production of basic types of tools in given plants, Melman notes. Some factories specialize in lathes, others in boring and milling machines. And even though emphasis is on standard machines, "special" units are also produced.

In the long run, Melman feels, Western European machine-tool manufacturers will be unable to meet competition of mass-produced Russian tools in world markets unless they, too, shift to mass production. But in his survey of the western machine-tool plants, Melman turned up no evidence that the shift was imminent. Management in the machine-tool industry seems more interested in maintaining the status quo—low-volume production by artisan methods, high prices and protected markets—he says. In Melman's opinion, the decision on how to meet the Russian threat is too important to be left up to management in the machine-tool industry and some sort of intervention by higher authority is necessary. ■

First Step Taken to Mechanize Translation of World's Technical Literature

CLEVELAND—A first forward step in developing effective mechanization for translation of the world's technical literary output was made here recently under the sponsorship of Western Reserve Univ and Rand Development Corp.

Billed as an experiment, the first International Conference for Standards on a Common Language for Machine Searching and Translation was attended by 200 persons representing 10 different nations (Brazil, France, India, Italy, Japan, Netherlands, UK, US, USSR, and West Germany). Representatives' backgrounds and interests ranged from those of the US Commissioner of Patents (Robert C. Watson) and the managing director of the American Standards Association (Adm George Hussey), to those of a member of the USSR's State Scientific and Technical Committee, USSR Council of Ministers (E. J. Levin), and England's Director of the Numerical Analysis Laboratory of Birkbeck College in London, (A. D. Booth).

Some 55 formal papers were presented, reviewing progress in machine literature-searching, correlation and translation. Proposals were presented

for intermediate, common and universal language, and for advanced application of computer information systems, in behavioral systems and in automation of the research process.

Sen Hubert H. Humphrey (D-Minn.), featured speaker, stressed the need for improved mechanized information services on a coordinated basis and for more cooperation within the US as well as among the various nations of the world. As chairman of the Senate Subcommittee on Reorganization (Committee on Government Operations), he deplored the slow start made by federal agencies in recognizing the problem created by the mushroom growth of literature and in taking effective steps to support new ideas for controlling it.

The technical discussions showed the effects of bringing together, for the first time, the leading thinkers of the several fields impinging on machine searching and translation. The continuing work of the Conference was assured by the formation of an International Committee on Information Retrieval and Machine Translation, composed of representatives of the 10 countries. The Committee will encourage continuing investigations in this field under 4 main headings; research, nomenclature, exchange of materials and information, and exchange of personnel.

The first technical announcement of General Electric's literature-searching selector, the GE-250, was made in a paper co-authored by C. D. Gull and Paul O. Dodge. The first of these transistorized tape-scanning devices will be delivered to Western Reserve Univ's Documentation Research Center in February, 1960, when it will have its first application as a part of the Metals Documentation Service which Western Reserve will operate for the American Society for Metals.

The Committee is headed up by England's Brian Vicery of Imperial Chemical Industries, who was elected president, and USA's Allen Kent of Western Reserve Univ, elected general secretary. Four vice-presidents were named from the Netherlands, India, Brazil, and the USSR. The Committee will seek sponsorship from existing agencies such as the International Standards Organization and the United Nations. —Allen Kent

Document-retrieval Device Developed

WASHINGTON—A machine to retrieve information from massive files of correspondence, drawings, patents or printed matter that has been recorded on 35-mm microfilm has been developed by the National Bureau of Stand-

More Mechanized Mail Sorting

Semiautomatic mail sorter, developed by Rabinow Engineering Co, *(PE—Mar 9, p 25)* and built by Burroughs Corp for Detroit Post Office, eliminates most of the manual "pigeon-holing" of mail by clerks. Operator sits at a 10-key board, and as each letter passes in front of him, taps out a prescribed numerical combination on console board. Illegible addresses are rerouted to a reject pocket by depressing all keys at once. Each piece of mail can be routed mechanically to one of 300 destinations. From operator's keyboard, letter drops into a tray positioned on a long conveyor which full-circles around the sorter cabinet. Tray is electromechanically designed to deposit letter into destination pocket at rear of sorter. Incoming mail stacks are loaded by hand into feeder conveyors at the end of each console. With

12 operators at work, system has a maximum capability of processing 54,000 pieces of mail per hr. Sorter consists of a basic block 78 ft long, 10 ft high, and 5 ft wide. The block houses the main sorting conveyor and destination pockets as well as 12 consoles (each, 7 ft tall) which jut out at right angles from the block. (Additional information about this sorter will appear in the next issue of PRODUCT ENGINEERING).

ards for the Patent Office and the Navy Bureau of Ships.

Basically, this is the way the machine works: Each document image has a binary dot code which identifies contents. The machine examines these codes rapidly—about 2400 pages per min—and, when it finds the desired document, photographs the contents on a strip of recopy film.

A single code frame is ¼ in. long and as wide as the film, and contains 6 rows of 46 bits each. Forty bits are required for document information; six for machine control. The mechanism that reads these bits has sufficient tolerance to allow normal dimensional changes in film and slight skew in the rows.

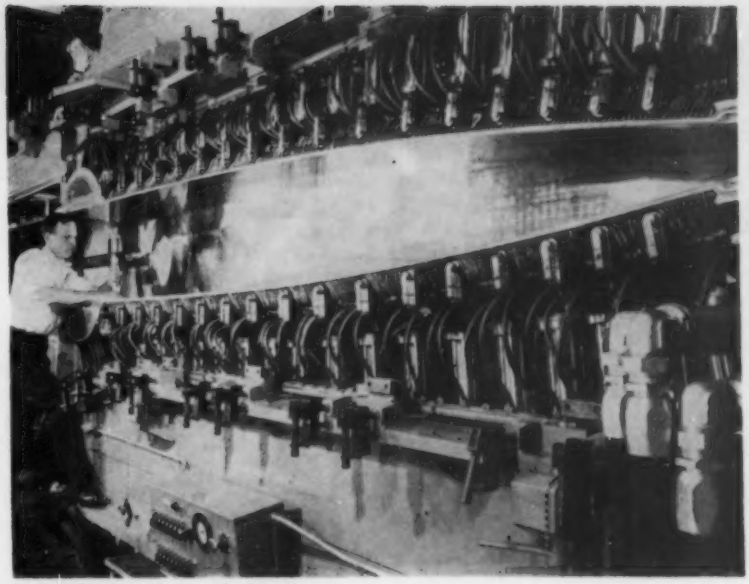
As the master film passes through the machine, its image is projected on a bank of photocells which scan the code. When the desired item is found, a high-speed clutch mechanism presses recopy film to a drive drum. This accelerates the drum to the same speed as the information or master film. After the item passes the camera slit, the clutch disengages and recopy film stops.

Proposed originally by Dr Vannevar Bush more than 20 years ago, a simplified form of the machine was designed for document searches at Yale University. The present NBS version includes some Yale equipment with modified optical and mechanical systems and electronic circuitry redesigned for computing machines. ■

Petroleum's billion-pounders

Compared with total output of oil, the production of chemicals-from-oil is barely a film on the barrel. But, latest government figures show more than a half dozen petro-chemicals are now produced in quantities of a billion pounds a year or more, and oil has become our major source of the benzene and toluene used in fuels and cleaning fluids of ethylene and polyethylene plastic, as well as of many basic chemicals used for paints, dyes.

Because these chemicals do represent a small but lucrative outlet for petroleum, their supply is assured, and they can and do take over when such conventional sources as coal (for benzene and toluene) are shut off.



Downstream view of nozzle . . .
of $3,500,000 hypersonic wind tunnel built by California Institute of Technology's Jet Propulsion Lab. Here, technician checks position of calibration probe.

NASA Wind Tunnel Achieves Air Speeds from Mach 5 to 9

PASADENA, CALIF—A continuous-flow hypersonic wind tunnel at California Institute of Technology Jet Propulsion Lab here, which can generate air speeds from Mach 5 to Mach 9, is equipped with a flexible, 2-dimensional nozzle.

While conventional nozzle throats are made of stainless steel, JPL's is made of solid, beryllium-copper blocks, selected for high strength and high thermal conductivity. The rectangle formed by the throat blocks determines the tunnel's operating mach number. For example, when tunnel is operating at Mach 9, the width of the rectangle is 17 in. but the height is only 0.045 in.

Curved surfaces of the blocks were machined to tolerances of 0.0002 in., had to be equipped with a cooling system capable of carrying 1475 gal. of water per min. at a velocity of 120 fps, and had to be rigid enough to withstand maximum supply pressure of 1000 psi at 1350 F.

The two tapering stainless steel plates at top and bottom of the nozzle are ½ in. thick, 14 ft long, 17 in. wide at the throat and 21 in. wide at the 21 x 21-in. test section. They can be contoured by a system of 16 hydraulic jacks to refinements of as little as 0.0005 in., can assume nozzle profiles to within 0.0002 in. of the theoretical shape requirement.

The tunnel, subsidized by the National Aeronautics & Space Administration, will be used to study stability and control problems on many of the nation's most advanced missiles and aircraft by means of force balances and pressure distribution measurements. In addition, heat transfer on practical shapes and the effects of such things as angle of attack, interfering flow fields and separated flow regions will be studied. ■

3 Compacts? No, 4

DETROIT—Latest newcomer to the burgeoning list of compact cars, another Ford product—M-E-L Div's Comet. It will be sold by Mercury dealers sometime this coming spring as a "1961" model, aimed at the market entered recently by Ford's Falcon, Chevy's Corvair and Chrysler's Valiant.

This 114-in. wheelbase, front-engine car will be powered by the same overhead-valve six now used in standard-size Fords and Edsels. A 292-cu in. V-8 will be optional.

Basic body structure of the Falcon

will be used, in 2 and 4-door sedan and 4-door station wagon form. Front and rear sheetmetal will be extended, bringing over all length to 195 in. Width will be 70 in. The car is described as highly styled, and will be more luxurious and therefore more costly than the Falcon.

This is the car that was long rumored as the Edsel "B", and later the Cougar. Introduction will be timed to match GM's forthcoming aluminum, front-engined V-8 compact car to be marketed next spring by Buick, Oldsmobile, and Pontiac dealers. ■

COMING EVENTS

OCTOBER

19-21 . . . . American Institute of Electrical Engineers, 11th Annual Machine Tool Conference, Sheraton-Cleveland Hotel, Cleveland, Ohio.

20-22 . . . . American Society of Lubrication Engineers, American Society of Mechanical Engineers, Lubrication Conference, Sheraton-McAlpin Hotel, New York.

21-23 . . . . Society for Experimental Stress Analysis, 1959 Annual Meeting, Hotel Pick-Fort, Detroit, Mich.

22-23 . . . . Illinois Institute of Technology, 15th Annual National Conference on Industrial Hydraulics, Sherman Hotel, Chicago.

22-25 . . . . American Society of Industrial Designers, Annual Meeting, Grove Park Inn, Asheville, N. C.

26-28 . . . . Office of Naval Research, 1st International Symposium on Gas Lubricated Bearings, Shoreham Hotel, Washington, D. C.

26-28 . . . . Society of Automotive Engineers, National Transportation Meeting, La Salle Hotel, Chicago, Ill.

27-28 . . . . Society of Automotive Engineers, National Diesel Engine Meeting, La Salle Hotel, Chicago, Ill.

27-29 . . . . American Society of Mechanical Engineers, Society of Mining Engineers, Joint Solid Fuels Conference, Netherlands-Hilton Hotel, Cincinnati, Ohio.

28-29 . . . . Armour Research Foundation, Computer Applications Symposium, Morrison Hotel, Chicago.

28-30 . . . . Society of Automotive Engineers, National Fuels and Lubricants Meeting, La Salle Hotel, Chicago, Ill.

29-30 . . . . Institute of Radio Engineers, 5th Annual Electron Devices Meeting, Shoreham Hotel, Washington, D. C.

Reader To Editor...

Saving Drafting Time

To the Editor:

We have used the "Painless Drawing Changes" method (Sept 14, p 83) for several years and find it fast, efficient and economical. Our changes are handled in the Engineering Clerical Dept where the supervisor and clerk-typist double as draftsmen. This has the advantage of the original remaining in the filing room and is less apt to become soiled or damaged; and new prints are made promptly.

Most of our changes are confirmed by "on the spot" or telephone conferences between an engineer and department head. The shop print is then removed from the shop file, the change marked in red and forwarded to the Engineering Clerical Dept upon completion of the run. The original is changed and new prints filed in the manufacturing and inspection departments.

The shop cannot start production run of a part until it receives a corrected print. If a backlog of changes piles up, they can be handled as the shop requests replacement prints. Changes on non-urgent drawings are then handled routinely. Our clerical department also checks on the ultimate use of the part to be certain that the change is feasible in every application, if the part is used in more than one product. Unless the problem is unusual, the engineer is involved only in the original conference and to initial the change after it is completed. Use of the shop print as a memo eliminates the need for an additional form, gives the complete picture to everyone involved, and guarantees that no parts will be made to uncorrected specifications.

—Clarence Murphy
Micrometrical Mfg Co
Ann Arbor, Mich

Who's Gumperson?

To the Editor:

I have a comment on the last paragraph of the story in "Interesting to Note," Aug 31, p 7. During WW II, I was a B24 pilot in Italy. These bombers evidently were properly checked out in cockpit design; they had large conveniently located ashtrays.

But Gumperson's Law still holds! Immediately above the ashtray was a blazing red sign in 2-in. letters which proclaimed, "No Smoking."

—Jack Gunn
Berkeley, Calif

Creativity

To the Editor:

Creativity (Aug 24, p 20) is a subject difficult to reduce to a formula or pinpoint to a definite procedure. The major weakness in the search for new information is the lack of knowledge to define the thing we are searching for. Some answers come quickly, depending upon the circumstances that make the answer necessary. Other answers may be obtained after years of testing things that others claimed should work but didn't.

Most people do not continue with research work because they cannot make a living out of it. This is an unfortunate situation when you think that the growth of our country has been built on new and novel things. Are we slowly getting the idea that we can coast along by only making more of the things we already have? What we need is some basic research in our present business and government practices that would permit all the bills to be paid by first eliminating all duplication of effort.

—Arthur L Koch
Elizabeth, NJ

To the Editor:

Your article on creativity in the Aug 24 issue, p 20, is the finest and most accurate description of inventors I have ever read. You show an amazing understanding of the strange creatures. I do believe, however, that our patent system needs revision in order to bring out important hidden inventions and ideas. I have suggested that a Register of Ideas be established in the Patent Office so that any inventor can record his invention and will have a period of grace in which to patent it.

There is one point in your article which does not agree with my experience. You seemed to indicate that inventors' imaginations become dulled with age. I have found that my imagination is even keener than it was 30 years ago and I am convinced that it is much sounder. I sat up nearly all of one night about 10 years ago and recorded more than 100 inventions which occurred to me spontaneously. I do not think I would have any trouble dreaming up at least two dozen inventions in one night at the present time.

—A G Thomas
Charlottesville, Va.

Metric System Fits the Circle

To the Editor:

The letter by C. Lauren Maltby, Sierra Madre, Calif, regarding a proposed modernized time system (August 6, p 26) has prompted me to bring up the problem of converting the present measurement system for a circle to a metric system. Under the present system we have no direct conversion of degrees, minutes and seconds. However, using a system similar to the one suggested by C. L. Maltby, this problem could be eliminated. If the United States is going to change to the metric system let's go all the way.

—D R Bross
Canoga Park, Calif

8 *steps to better engineering writing...*

1. . VANITY AND LAZINESS, BE SIMPLE
2. . BE POSITIVE, BE BRAVE
3. . BE PERSONAL, BE SPECIFIC
4. . BE CONCISE, DON'T OVERSTATE
5. . VOCABULARY, GRAMMAR, PUNCTUATION
6. . TABLES, FIGURES, CAPTIONS
7. . WHERE TO PUT WHAT
8. . SIT DOWN AND WRITE

RICHARD M. KOFF, *senior associate editor*

Lesson . . 6

How long is a letter, a report, an article? You can count the number of words or pages for an objective total, which might satisfy your engineering instincts—but it will be worthless. The length of a report is measured by your reader's first quick glance. He estimates how long it will take him to read, weighs this against the value or pleasure the subject seems likely to give, and decides whether to read, scan, or ignore.

Good appearance is the best persuader (right after subject matter). Clean typing and well-thought-out illustrations should not need mentioning here, but some common-sense pointers will bear repeating.

TYPED COPY

Only letters should be single spaced. One page of closely typed information, generously bordered in white space, will seem to be only a couple of minutes' reading, and a personally addressed letter is difficult to resist. But be very cautious about running over to a second page. How many such letters have you started to skip through, or hesitated even to start, just because the mass of words was discouraging?

In longer reports, paper economy never justifies single spacing. If the shear weight of a double-spaced report becomes a factor, you've probably written too much. Circulate the conclusions and file the rest.

TABLES

One problem with tables is that they force you to be logical. If you've skimped on an experiment or you don't like the way your product shows up in comparison with the competitor's, it will be difficult to cover up in a table. However, engineers are wild for tables; they collect them the way squirrels save nuts. So it may pay to do a little more research just to have a good table in your report.

Use tables whenever you have four or more sets of data. Even qualitative and descriptive matter can be put in tabular form to advantage.

Use summary tables in the body of a report, details in the appendix.

All tables need title and number (usually roman).

Identify all columns and rows, indicating units where applicable. Note that "inches x 10^{-2}" may be misleading. Should you multiply the listed figure by 10^{-2} or divide? Make sure the reader knows what you mean.

Use the same units for comparable quantities.

Align columns on the decimal point for similar units. Do not align for different units.

Number footnotes across a row, then down and across the next row.

Similar tables should have similar format.

Do not use ditto marks; repeat the figure.

Use a 0 before the decimal point on numbers less than 1 (0.435). Add a comma after the third zero in decimals (0.000,34).

FIGURES

Time and effort spent on good illustrations are as much or more important than time spent on writing. Most people, engineers included, look at the pictures first.

Graphs are better than tables to show trends. The danger here is excessive detail (limit ordinates and abscissas to about half-inch spacing if possible), or too many curves per graph. Curves should be several line weights heavier than the ordinate lines. Use different colors for a one-copy report, different line styles (dashed, dotted, etc.) for reports to be reproduced.

Charts, like bar charts, pie charts and the like, are a bit unsophisticated for an engineer reader, but management and advertising men tend to be impressed. If you must, go whole hog. Use color bars of pressure-sensitive tape or other gimmicks available from your local art-supply store.

Diagrams, cutaways, perspectives, isometrics, even cartoons are all lovely because they transmit a lot of information quickly or a little information powerfully. Keep them simple.

Photographs, the picture-in-a-minute variety particularly, spark up a dull report and make reading a pleasure instead of a chore—if they show something important.

Illustrations must be edited too! The first sketch is just as unsatisfactory as a first draft of a manuscript. Take the time to pare it down to the essentials (retake the picture if necessary). Does the most important information dominate the page?

Any flipping to and from the text should be avoided if possible. Paste the figure right where it belongs in the text or paste it on the right-hand edge so that it can be folded out clear of the report.

Don't get carried away by illustrations. A picture may be worth 1000 words, but 10 pictures are not worth 10,000 words.

CAPTIONS

To be of any use at all, illustrations must be self-explanatory. Captions can do this for you. Here are some pointers:

Never start with "A photograph of . . . " or "A drawing of . . . " The reader can figure that out for himself.

Make the caption something more than a tag or label. Point out what is significant about the figure. Account for every important element, and tell where it is, too (top, right, left).

Be concise. A long caption competes with its illustration, particularly when it repeats the text.

***Reprints** of this series will be available at the end of October. To reserve your copy, Circle P15 on the Readers Service Card.*

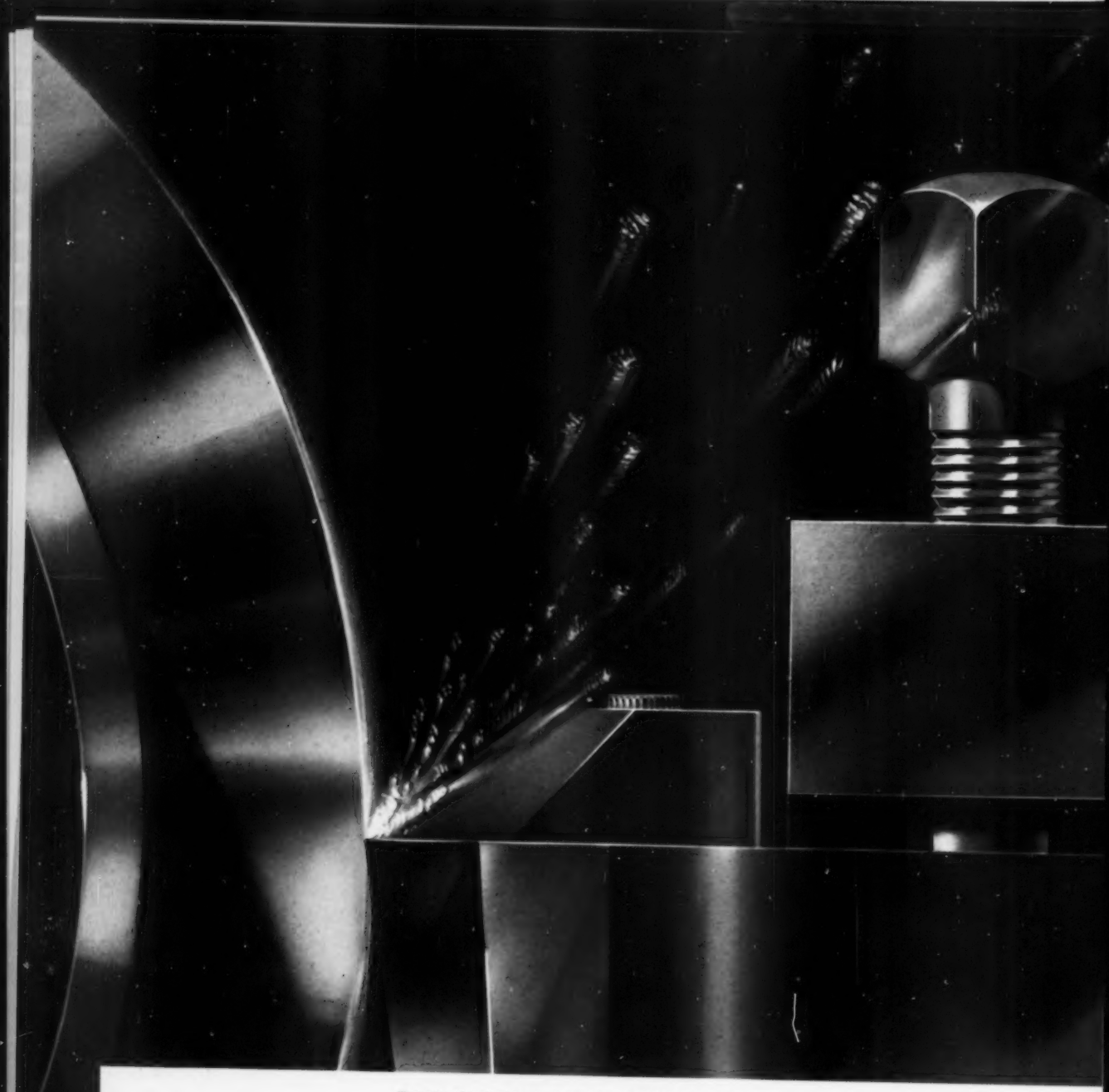


Illustration of Malleable casting being turned at 1,400 surface feet per minute with a 0.100" depth of cut using an oxide tool.

Machinability is Malleable

It's the finished cost of machined components that's important to you. Remember then . . . Malleable iron is more machinable than any other ferrous metal of similar properties. With Malleable castings you'll reduce machining time as much as 50% . . . increase tool life up to 250% . . . get unexcelled surface finishes . . . and end your reject problems.

To find out how much you can cut your costs and improve your profits, contact one of the progressive firms that displays this symbol—

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If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

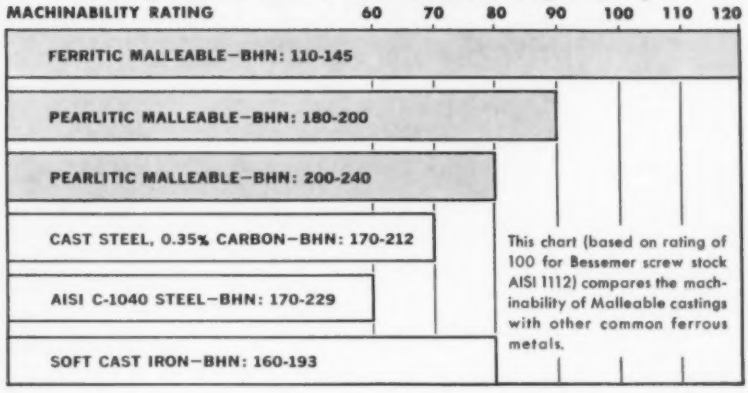
Machining Malleable Castings—Important Key to Cost Reduction

Malleable castings—the most machinable of all ferrous metals—cut quality components costs

Production men know that machining time, power consumption and rejects drop with the use of Malleable iron castings, while tool life and profits shoot up. The reason is simple: Malleable iron is the most machinable of all ferrous metals of similar properties.

The following important factors work together to give Malleable such machining superiority: Malleable's microstructure contains tiny, evenly distributed nodules of carbon that help cutting tools quickly break the removed metal into small (Class A) chips; the carbon also acts as a lubricant, prolonging tool life; uniformity of properties throughout every casting permits running at optimum machining conditions.

Comparison Shows Malleable's Superiority



Typical Example Shows Savings of 70% to 250%

The conversion of automotive universal joint yokes from steel forgings to pearlitic Malleable castings typifies the savings provided by Malleable castings. Costs for the rough pieces and performance characteristics of the two materials are comparable. However, the castings are much more economical to machine. Considering that machining often costs two to four times as much as the rough parts, the economy resulting from using Malleable castings is substantial.

Conversion of this universal joint yoke to a Malleable casting increased production, lowered direct and tool room labor, and cut tool replacement.

One volume user of Malleable joint yokes reports the following savings after changing from steel to Malleable castings: 70% longer tool life in broaching the splines; 250% more pieces cut by the nut seat cutters; 149% more pieces in turning and facing the hub; an increase of 100% in production between wheel dressings in grinding the hub; 246% greater production in drilling the cross holes.

In each of these operations, the change to Malleable castings cuts direct production time by reducing the frequency of tool changes. Tool room labor and tool replacement are both reduced to fractions of their previous costs.

Throughout the metalworking industry, part after part is now being initially designed of Malleable or converted from other materials to take advantage of Malleable's unrivalled machinability . . . to produce better parts at lower costs.

New Information Now Available on Machining Malleable

Data Unit 106—Machinability of Malleable Castings—can be obtained from any member of the Malleable Castings Council, or from the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

These companies are members of the

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CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
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MINNESOTA
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Canton Malleable Iron Co., Canton 5
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WEST VIRGINIA
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WISCONSIN
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Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

What will they think of next!

. . . what new modifications of the Fenwal 541 Temperature Controller will equipment designers ask for?

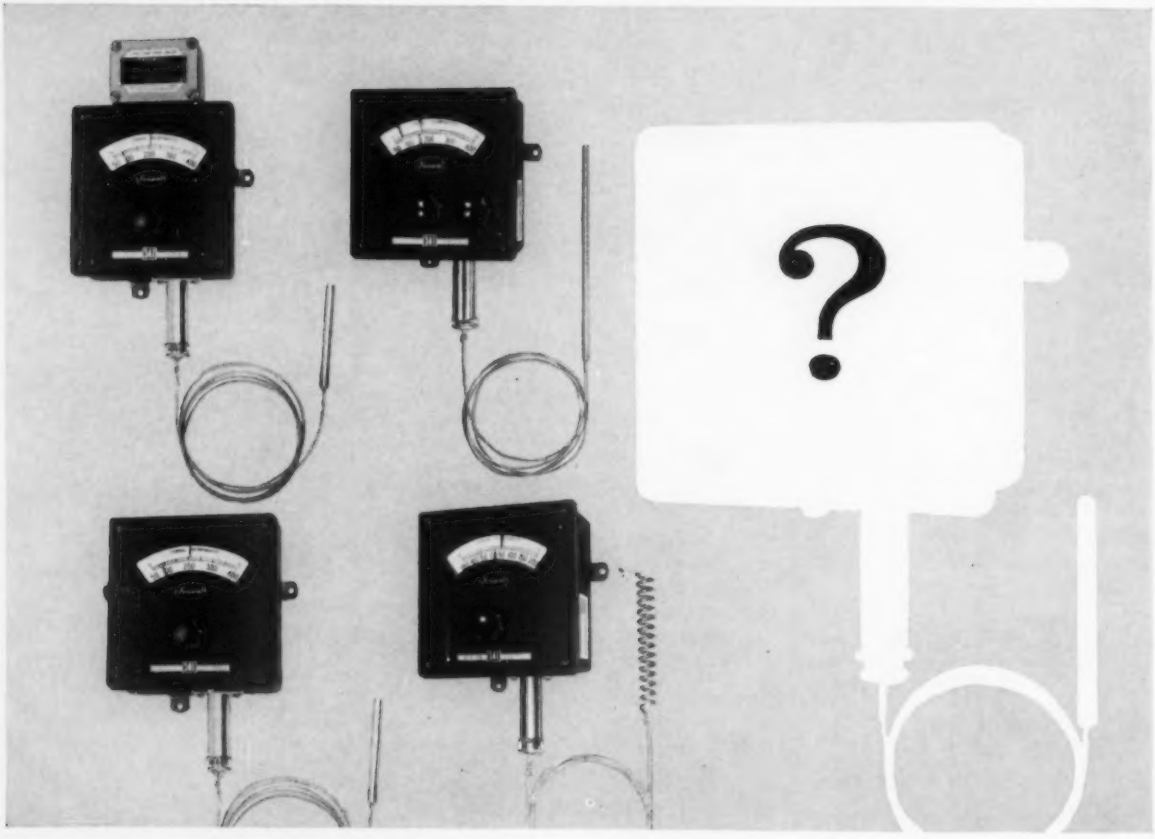
Luckily our engineers designed this liquid-filled bulb and capillary tube indicator controller for easy adaptation. It's been specified for applications ranging from gas burner control to fuel temperature control in missile ground support equipment. *Yet, basically, it's always the same, simple "black box"!*

The secret is case space. Room for up to 3 snap switches providing 3-point control. Nine-pin connector available for quick connect/disconnect to power source. Choice of 5 standard temperature ranges between −150° to +700°F (or special ranges). *Can control as many as four circuits simultaneously!*

Also . . . welded steel, splash and dust resistant case in black or gray crinkle finish, white enamel, or special color. Available completely fungus resistant. Mounts flush or on panel. Pilot light, if desired and . . . *every detail for each specific application!*

Design this competitively priced, high-efficiency controller into *your* product. Details from Fenwal Incorporated, 210 Pleasant Street, Ashland, Massachusetts.

All moving parts of the rugged Fenwal 541 Temperature Controller operate in opposition . . . compensate for wear and maintain perpetual high accuracy. Ratings: 15 and 20A-125-250VAC; .50A-125VDC; .25A-250VDC.



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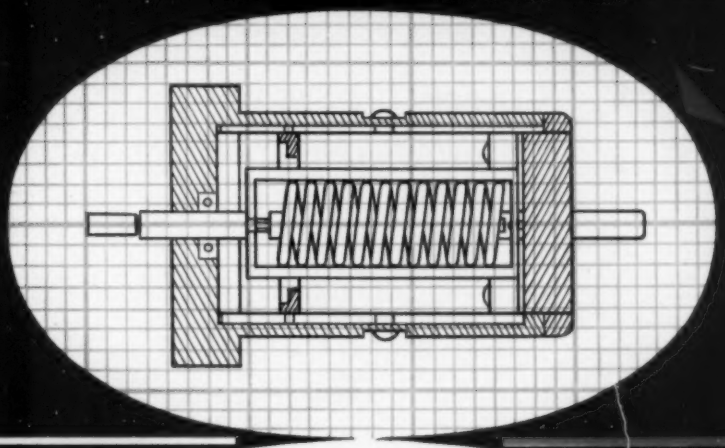

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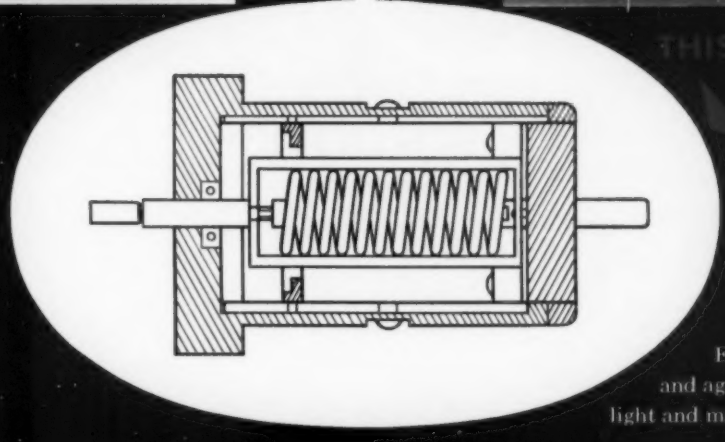

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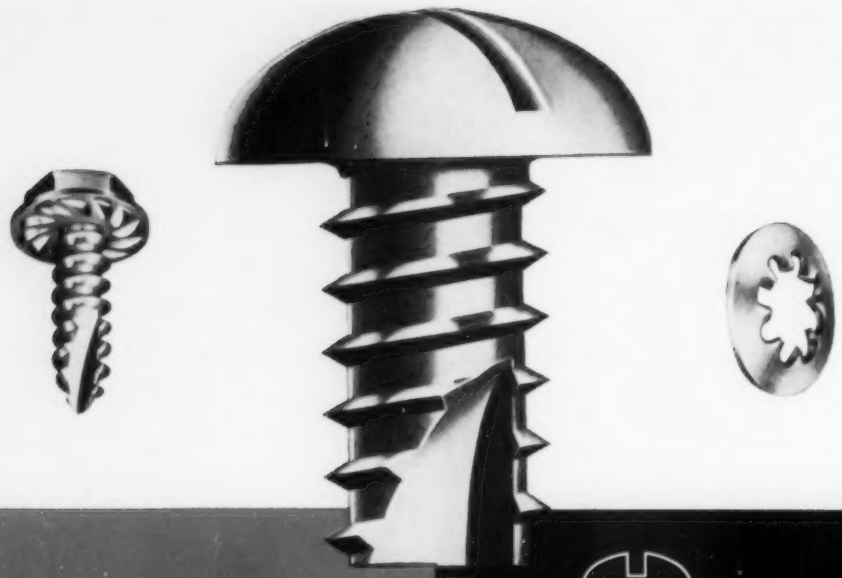
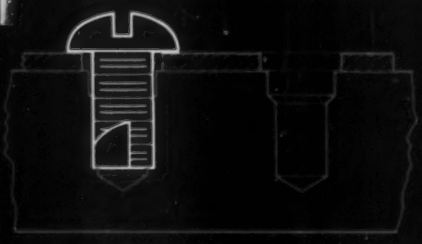


HOW TO SELECT COST-SAVING

fasteners for plastic



A TYPICAL EXAMPLE:
Cuts its own thread—

Shakeproof's® Type 25 Thread-cutting Screw saves time because it eliminates tapping. Blunt point assures maximum thread engagement and high holding strength when driven into a relatively thin panel.

Shakeproof has pioneered in developing ingenious, cost-cutting fasteners for plastic applications. The screw featured above not only taps its own hole—often it eliminates costly threaded inserts. Another Shakeproof development, the Type 17 self-drilling Nibscrew®, both drills and taps as it is driven. A Shakeproof Dished Lock Washer compensates for differential in expansion between plastic and metal . . . temperature changes won't loosen the assembly.

For highest quality fasteners that assure faster assembly and lower costs investigate the Shakeproof line. There's a Shakeproof fastener to meet your need—or Shakeproof engineers will develop one for your specific application.

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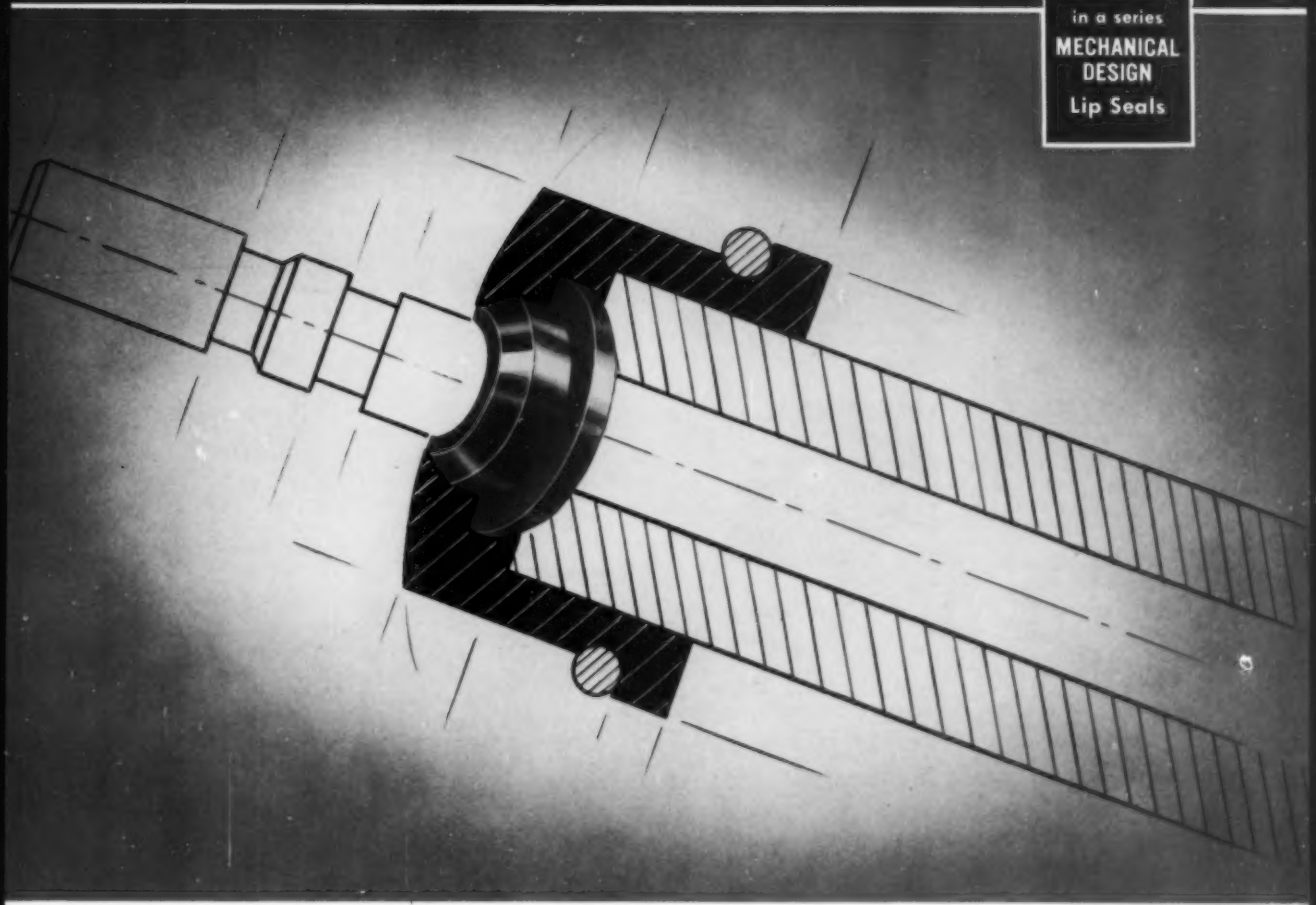
DU PONT

ENGINEERING FACTS ABOUT

TEFLON®

FLUOROCARBON RESINS

Number M-4
in a series
MECHANICAL
DESIGN
Lip Seals



Lip seal of a TFE resin provides oil seal with low friction . . . low wear . . . longer life

The valve guide seal, shown enlarged above, is used as an oil-control ring in automotive engines. Made of a TEFLON TFE fluorocarbon resin, the seal stops the passage of liquid oil, but, by acting as a lubricant itself, assures low wear of rubbing surfaces, has a long effective life, and stops burn-up of oil.

In all types of lip seals, the exceptionally low static coefficient of friction of TFE resins—less than 0.04—is a significant design advantage. It often makes possible the use of non-lubricated seals, with resultant savings in time, maintenance and the elimination of contamination problems. In addition, TFE resins offer exceptional resistance to corrosion and maintain their unique properties over a wide temperature range. But even when adverse conditions are not present, lip seals made with TFE resins offer the designer increased performance reliability, freedom from costly maintenance problems, longer effective seal life and, frequently, opportunities for simplified design.

On the next page you will find additional information on the properties of TFE resins that make their use in lip seals advantageous, and notes on the use of these resins in the various types of lip seals.

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

OVER

Lip seals of TFE resins: DESIGN CONSIDERATIONS

TEFLON TFE resins are being employed in all types of "automatic" seals, including cup seals, rod seals, "U's", "V's" and squeeze-type seals such as "O"-rings. There are many modifications by various processors of TFE resins in making these types of seals, and where specific problems occur, these suppliers stand ready with their products and experience to solve the problem. Considered below are the basic characteristics of TFE resins that have enabled designers to lengthen the life, broaden the use and improve the design of all types of automatic seals.

Relevant properties

1. Low coefficient of friction. TFE resins are unique in having a static coefficient of friction even lower than the dynamic value of 0.04, thus eliminating problems of stick-slip. At high loads and low velocities TFE resins have a lower friction than any other solid material, including graphite and molysulfide. They have a significantly lower static friction (as low as 0.016) than the best lubricated metal rings.

2. Temperature resistance. The exceptional thermal stability of TFE resins makes them suitable for continuous service at 500°F. At this temperature, and also at very low temperatures, they exhibit the same low frictional properties as at room temperatures.

3. Chemical inertness. TFE resins are completely inert to virtually all chemicals and solvents, such as strong caustics, sulfuric and hydrofluoric acids, aqua regia, aliphatic and aromatic gasolines, alcohols, esters, ketones and ethers up to their boiling points.

4. Other properties. TFE resins in seals are tough, abrasion-resistant, and have the ability to imbed hard foreign particles without apparent effect on the cylinder or on themselves.

The use of TFE resins for various types of lip seals

The unique combination of properties offered by TFE resins makes it possible for the designer to realize fully the advantages inherent in each of the basic types of lip seals:

Cup Seals: When reciprocating plungers and pistons weave through small misalignment, cup seals of TFE resins are used to solve the problem. They are also used for service with liquids and gases where large clearances, less machining time and simplicity of design are desirable. The exceptional frictional properties and self-lubricating properties of TEFLON make operation without lubrication possible. Cup seals made of TFE resins are available in a complete size range, and are made by machining, molding or postforming. Postformed seals have built-in stresses that make up for problems caused by thermal cycling which may arise when operating temperatures vary by more than 130°F.

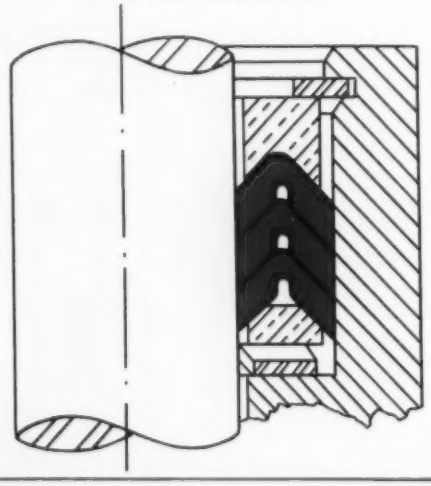
Rod Seals: In general, the same design considerations apply to rod seals, or flange packings, as for cup seals. They are also used for either reciprocating or rotary motion. Rod seals made of TEFLON resins are particularly useful when small space is required.

"U" Seals: A combination of the cup and rod seal designs, "U" seals made with TEFLON have been used successfully in applications where it is desirable to eliminate excessive packing friction at low operating pressures without narrowing tolerances. They may be applied to piston rods to prevent the entrance of air into the cylinder. They may also be used as wiper rings to remove dirt and dust from rods. Here the ability of TFE resins to imbed particles further reduces wear and assures longer life.

"V" Seals: Another common type of automatic sealing device embodying TEFLON is the spring-actuated "V" ring set shown in Figure 2. These rings are similar to a "U" seal, but more rings are used in the housing. This design has more sealing edges which lessen the danger of shutdown because the next ring can take over when a ring fails or is damaged.

Male and female adaptors are available to place at the ends of the "V" ring seals. They are used to prevent the rings from deforming under extremely high pressures in the case of the female and to insure automatic lip action and a positive seal under pressure in the case of the male adaptor.

FIG. 2. V-RING SEAL ASSEMBLY



Other design considerations

In lip-type seals of TEFLON TFE resins, it is preferable that surface speed be limited to 600 feet per minute for unlubricated rotating shafts, since heat removal is a problem. On reciprocating movement, heat dissipation permits greater surface speed. A finish of at least 16 rms is preferred on both moving and static surfaces.

FOR MORE INFORMATION...

Further details on the properties and design characteristics of TEFLON TFE fluorocarbon resins, and their application to lip seals and all types of seals, may be obtained from your local supplier. You'll find him listed under "Plastics—Du Pont" in the Yellow Pages. Supplementary engineering data on the properties of TFE resins is available on request from your supplier or from: E. I. du Pont de Nemours & Co. (Inc.), Advertising Department, Room T-3610, Nemours Bldg., Wilmington 98, Delaware.

In Canada: Du Pont of Canada Ltd., P.O. Box 660, Montreal, Quebec.

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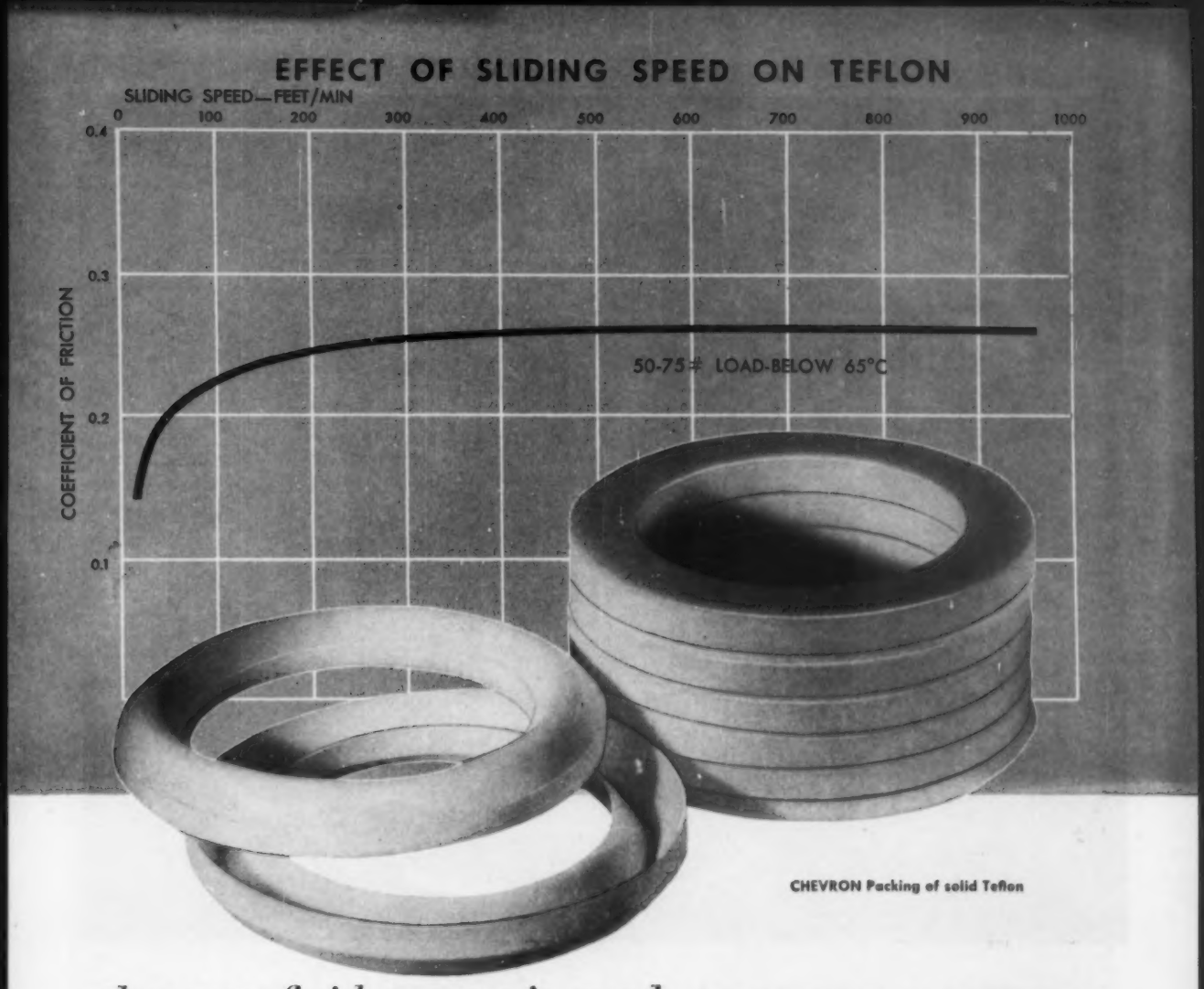
TFE-FLUOROCARBON RESINS

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*



CHEVRON Packing of solid Teflon

wherever fluid power is used—GARLOCK PACKINGS OF TEFLON* MAKE A BIG DIFFERENCE IN EFFICIENCY

Friction, wear practically eliminated. Garlock CHEVRON† Packings of solid Teflon—or coated with Teflon—are as close to "frictionless" as you'll find. First of all, Teflon has the lowest coefficient of friction of any solid material in use today. Moreover, the CHEVRON itself is designed to permit free operation with minimum friction at all pressures. Here's how: with increasing pressures, CHEVRON Packing rings tighten to prevent leakage. As pressures decrease, the rings instantly ease off, permitting free operation of the rod, ram, or piston without leakage. This exclusive hinge-like construction lengthens packing life and, with proper installation, eliminates all further adjustments necessary to compensate for pressure variations.

Teflon-coated Cups reduce breakaway torque, completely eliminate "squealing."

Teflon-coated Cups, Teflon "V" Rings, "O" Rings wear longer, reduce friction, are tough, resilient. Solid-Teflon packings are chemically-inert, non-flammable, can be applied against all hydrocarbons and new synthetic hydraulic fluids at temperatures ranging from −100°F to +500°F.

Discuss Garlock Teflon Packings with your local Garlock representative. Call him, or write for Catalogs AD-115 (CHEVRON Packings), AD-148 ("O" Ring Packings), and AD-145 (Molded Cups).

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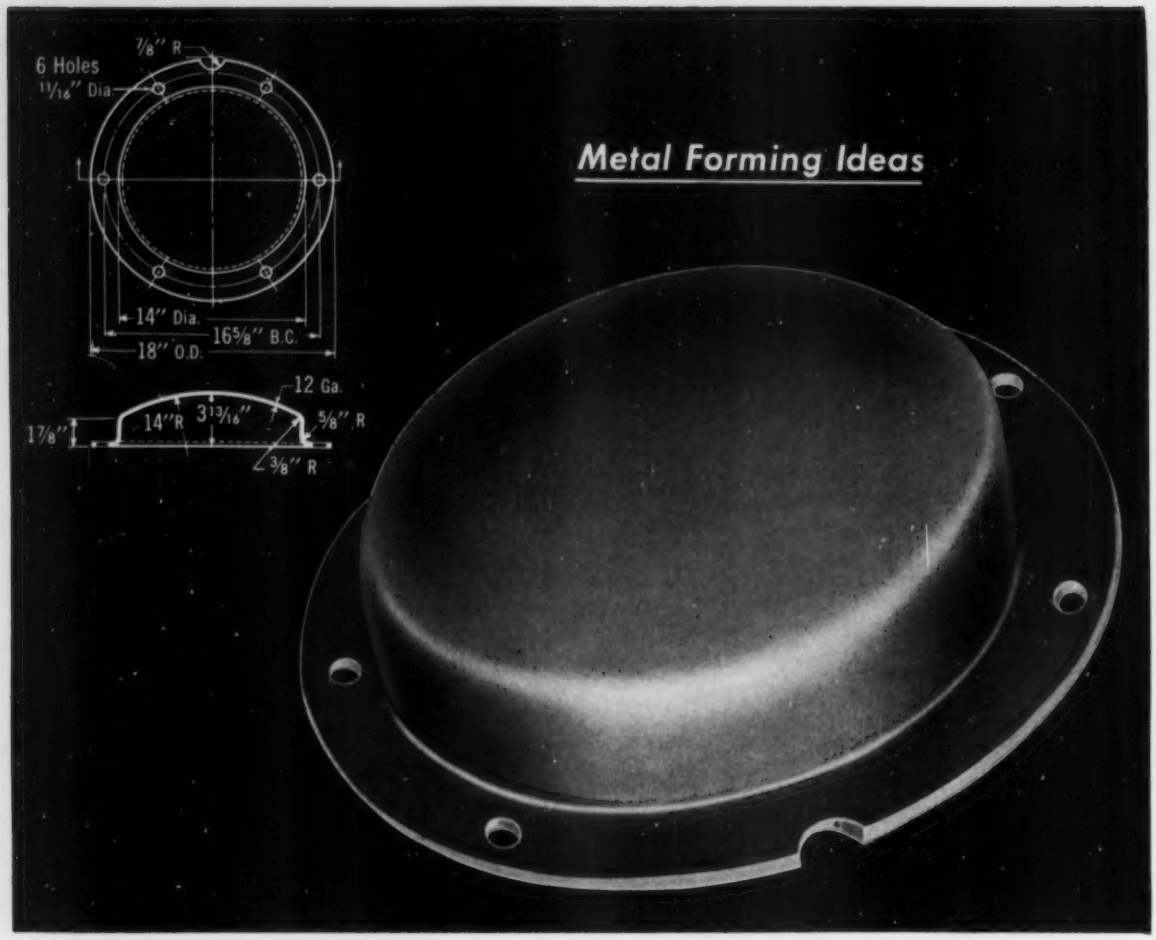
←CIRCLE 50 ON READER SERVICE CARD

CIRCLE 51 ON READER SERVICE CARD 51



How to eliminate special tooling in the design of custom-formed parts

Custom stampings, formerly prohibitive cost-wise, can now be inexpensively formed through the use of existing dies from COMMERCIAL's "Die Bank" of almost 50,000 different forming die components.

A case in point: Wheel covers for American Coleman's aircraft towing tractor. They're important for the protection of the power transfer yokes in the tractor's four-wheel drive.

Stamping was first considered as the best method for forming them. The original low quantity involved and the amortization of $2,300 for special forming die costs, however, made the stamping unit costs impractical.

The covers were therefore first produced as machined, malleable iron castings at a cost of $8.49 per unit. A switch to hand spinning later reduced this cost to a still high $3.50 per cover.

American Coleman then discovered and investigated COMMERCIAL's "Die Bank". From 24 basic shapes ranging 4" to 72" in diameter and involving metal thickness from 20 gauge to ¾" —all available through the use of existing dies adapted to presses up to 2000 ton capacity—emerged an entirely practical and economical solution to the unit cost problem.

The design: A standard, dished, offset shape with vertical and horizontal flanges and dish radius equal to its dished diameter. The wheel cover of 12 gauge, stamped steel now provides complete protection, necessary yoke clearance and a pleasing appearance.

Best of all, by using an existing forming die from COMMERCIAL's "Die Bank", the actual tooling charge was only $80 for a simple modification of a single die component. And the unit cost was slashed to a practical $2.59.

The final result: A strong, lightweight wheel cover with a smooth surface for finishing which now completely and economically meets all requirements.

If your component requirement involves a custom-formed or unusual shape, and if the high cost of tooling prohibits its economical forming, the "Die Bank" service at COMMERCIAL may be just what you've been looking for. There's a quick way to find out. Just send along a blueprint, sketch or prototype of your part to Commercial Shearing & Stamping Company., Dept. G-42, Youngstown 1, Ohio.

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Relay Life and Reliability

NEW
Bulletin 700, Type B-220A, AC Control Relay with 2 N.O. and 2 N.C. contacts.

NEW
Bulletin 700, Type BX-440A, AC Control Relay can be wired for normally open or normally closed contacts.

NEW ALLEN-BRADLEY BULLETIN 700 RELAYS

Improved features set new performance standards

For years, Allen-Bradley Bulletin 700 Type B and Type BX relays have been preferred for their long life and trouble free operation. The improvements in the new Bulletin 700 Type B and Type BX relays will set new performance standards wherever they are used. Naturally they use the famous A-B double break, silver alloy contacts which always remain in perfect operating condition without cleaning or filing. The cast coil cannot be damaged by the severest atmospheric conditions.

These new Allen-Bradley Bulletin 700 Type B and Type BX relays offer even greater value and greater reliability than ever before—but the price has not been changed.

- **New mechanical design gives at least 5 times greater operating life.**
- **New contact motion provides 10 times greater electrical reliability.**
- **Complete interchangeability—mounting dimensions are unchanged.**
- **New hermetically sealed plastic coil fits Bulletin 700 relays presently in use.**
- **New, stronger, movable contact crossbar—also fits old relays.**
- **New reinforced stationary contact blocks—interchangeable with previous design.**

Allen-Bradley Co., 1329 S. First St., Milwaukee 4, Wis.
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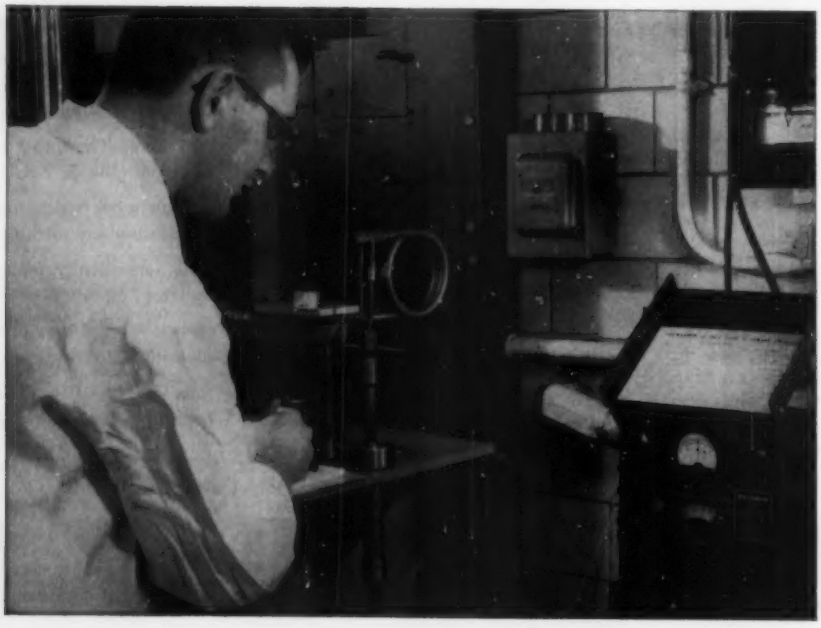
ALLEN-BRADLEY Quality Motor Control

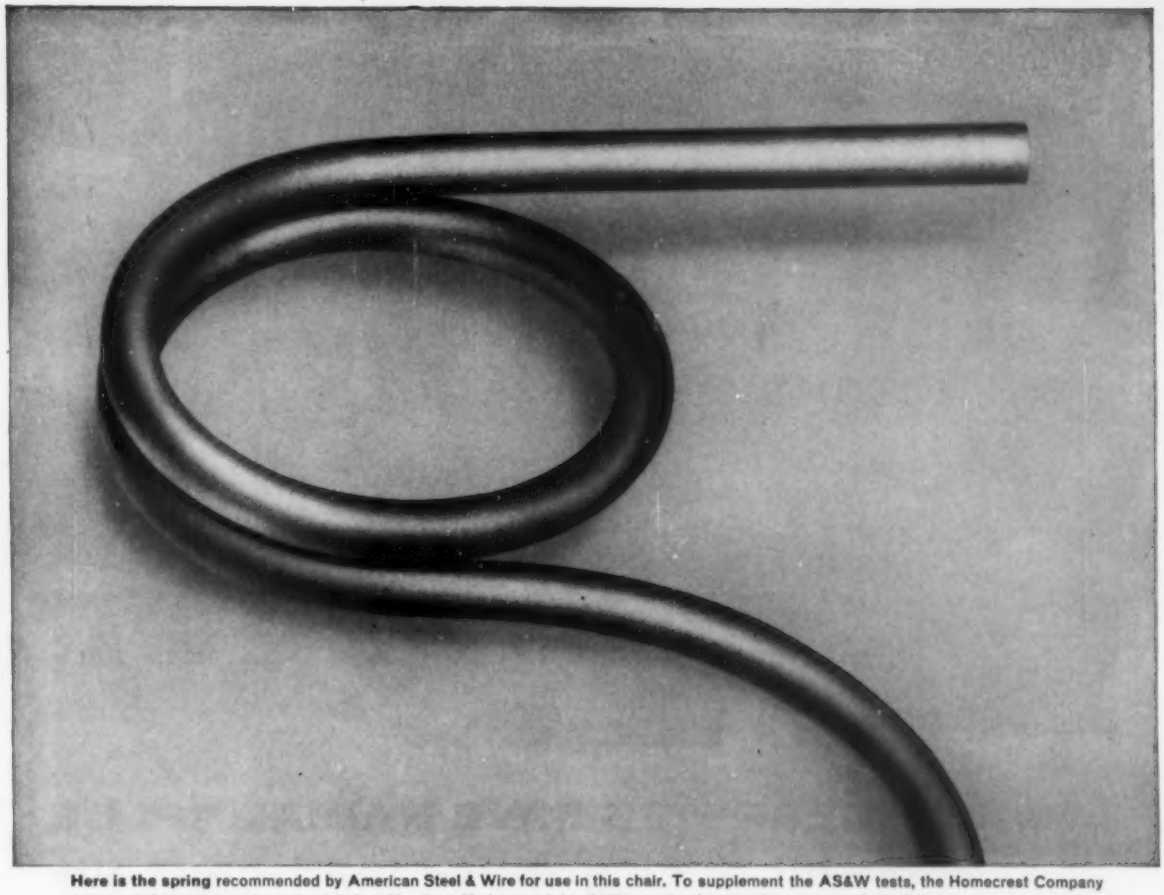
CIRCLE 53 ON READER SERVICE CARD 53

20,000 chairs rock on USS American Springs without one failure

...thanks to AS&W

In the American Steel & Wire Spring Testing Laboratory, the springs recommended for the Homecrest Chair go through extensive tests. This Fatigue machine, by means of strain-gauge verification, simulates years of use in a relatively short testing time.





Here is the spring recommended by American Steel & Wire for use in this chair. To supplement the AS&W tests, the Homecrest Company subjected these springs to a simulated rocking test. Under a weight of 250 pounds, these springs were rocked 750,000 times, without failure.

Spring Engineering Research Service

The Homecrest Company, Wadena, Minnesota, wanted to add a swivel rocking chair to their line of modern, functional home furniture. However, they would produce this chair only if it could be a quality item that would give good, dependable service. While designing the chair, they checked with the American Steel & Wire Spring Engineering Consulting Service. The engineers studied the problem, ran extensive tests and finally recommended a pair of round wire helical single coil torsion springs. Using these springs, Homecrest designed, fabricated and marketed the chair. Today 20,000 of these chairs have been sold and not one failure of an AS&W Spring has been reported.

Mr. A. L. Englemann, a partner of Homecrest Company, says, "We have purchased from American Steel & Wire over 45,000 springs, and not one has been reported a failure. We couldn't be happier with American Steel & Wire as a supply source for our springs."

If you have a spring problem, or would like advice on the use of springs in your product, get in touch with any American Steel & Wire Sales Office. You can benefit from the knowledge of AS&W's Spring Engineering Research Service. The Service has been engaged in laboratory experiments of static and dynamic testing for 20 years and has accumulated invaluable data on stress and fatigue life of steel springs, while endeavoring to improve efficiency in the use of steels, from steel chemistry through product application, to more economically cope with today's rigorous demands. This accumulated knowledge of the AS&W Spring Engineering Research Service is at your disposal. *American Steel & Wire, 614 Superior Ave., N.W., Cleveland 13, Ohio.*

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American Steel & Wire
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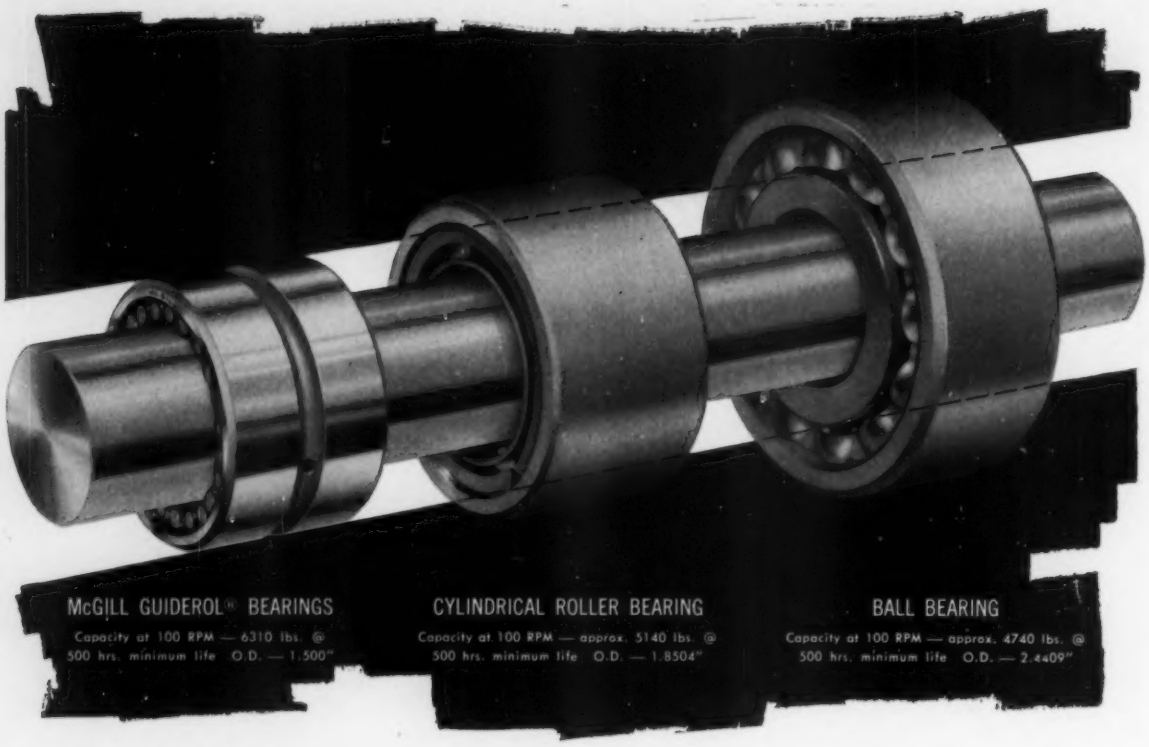
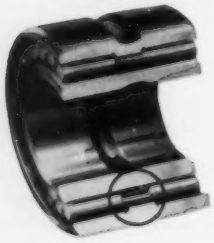
Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, Distributors Abroad


McGILL GUIDEROL® BEARINGS
Capacity at 100 RPM — 6310 lbs. @ 500 hrs. minimum life O.D. — 1.500"
CYLINDRICAL ROLLER BEARING
Capacity at 100 RPM — approx. 5140 lbs. @ 500 hrs. minimum life O.D. — 1.8504"
BALL BEARING
Capacity at 100 RPM — approx. 4740 lbs. @ 500 hrs. minimum life O.D. — 2.4409"

GUIDEROL® BEARINGS SAVE RADIAL SPACE
.....and still offer greater load capacity

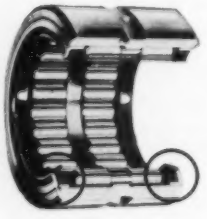
This graphic illustration demonstrates the radial space saving advantages of McGill GUIDEROL bearings that offer still greater capacity than the other two types of bearing compared. For a common 1" shaft, the GUIDEROL bearing GR-16 has an O.D. of only 1½" with a capacity of 6310 lbs. Compared to a cylindrical type roller bearing the GUIDEROL bearing requires ⅜" less housing space and offers 23% more capacity. A ball bearing for the same shaft uses almost an inch larger O.D. to carry 1500 lbs. less radial load.

CENTER GUIDED ROLLERS



GUIDEROL bearings pack more performance into smaller radial space. Their construction offers the inherent high capacity of a full complement needle bearing combined with effective roller control. Center guided rollers limit roller skewing tendencies and prevent binding under adverse conditions in either horizontal or vertical mountings. This qualifies GUIDEROL bearings for applications which are too heavily loaded for retainer type needle bearings, but are subject to misalignment that precludes the use of unguided needle bearings. Standard GR series GUIDEROL bearings are available, with or without inners, in shaft sizes from ⅝" to 9¼" with capacities ranging from 2880 lbs. to 128,670 lbs. (at 100 RPM).

LUBRICATION LOCKED IN, CONTAMINATION OUT; IN SEALED GUIDEROL BEARINGS



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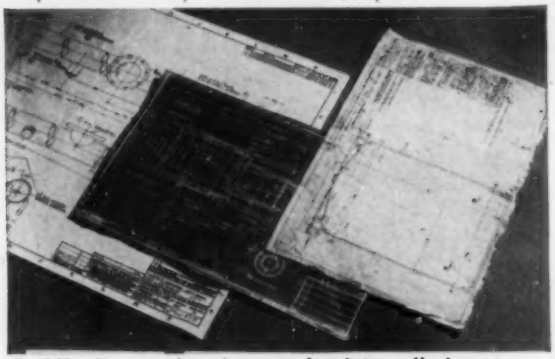

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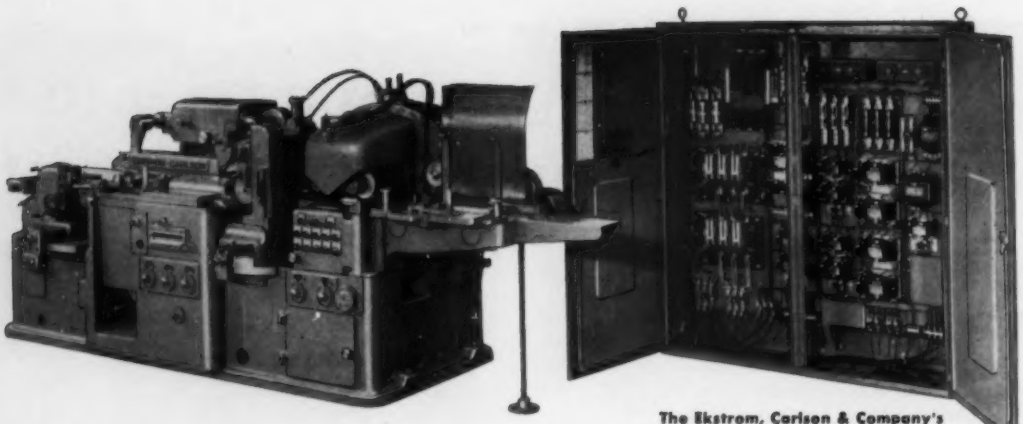

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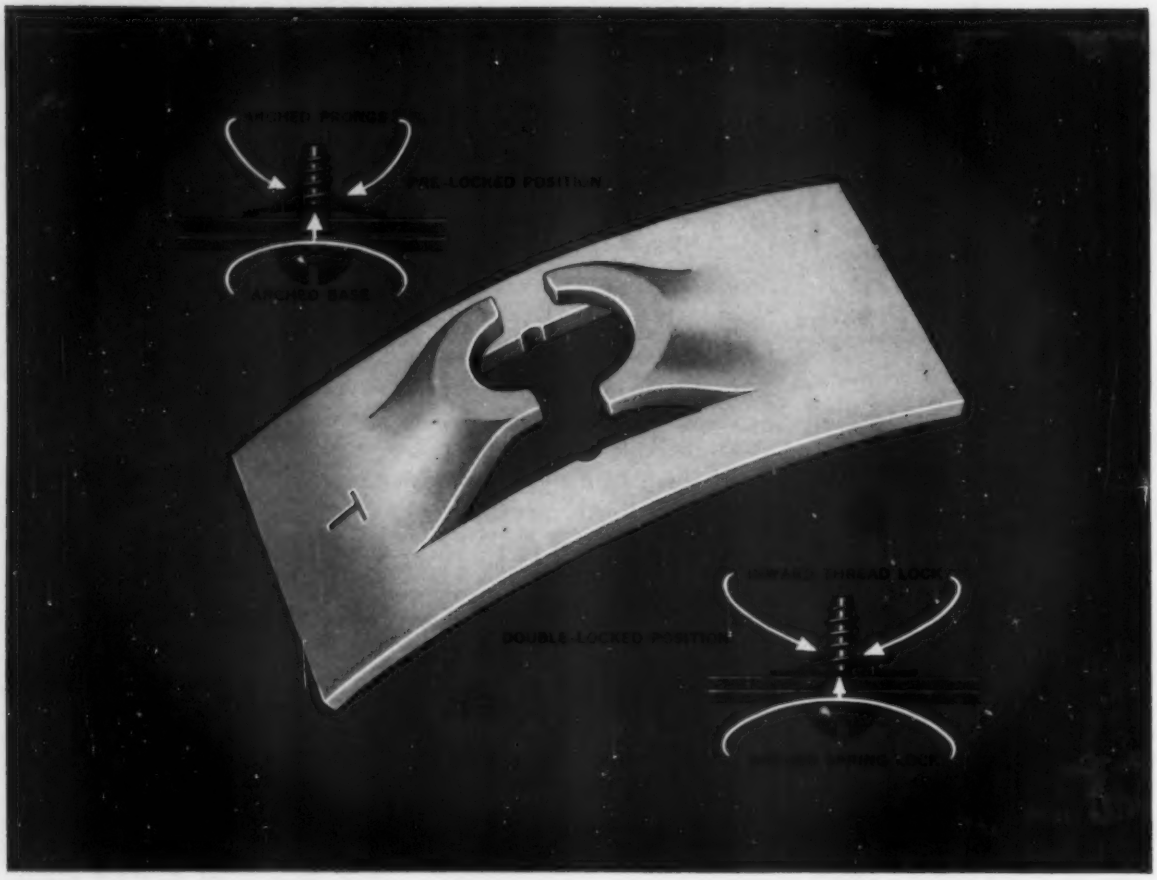

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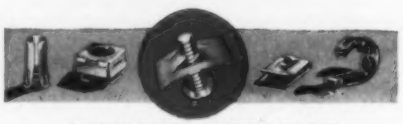

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Product Engineering

HORIZONS

October 12, 1959

HOW MUCH RELIABILITY?

Reliability used to be a black-and-white word. A company or a product or a storekeeper or a friend was reliable, another was not. The word, like "pregnant," did not admit of degree; one simply measured in terms of feeling or experience.

Not so anymore. Reliability has become a measurable quantity in the Missile Age, even though we can't yet define it. One electronics maker calls it "the probability that a system or component will do what it is supposed to do for a specified operating time." But that is incomplete, because another factor which must be considered is cost, still another is suitability.

Thus the exact material may be gold, but the required quantity costs or weighs too much, so some alternate, less reliable but lighter and less costly, may have to be selected instead. The major question then is, "How reliable is it?"

Missiles makers on the West Coast told me some time back that reliability data are readily available on electrical and electronic components such as switches, relays, tubes, transistors and transducers. The source company has made the necessary exhaustive tests. But on mechanical parts such as bearings, seals, shafts, cams, pumps and gears, the data are hard to get if they're available at all. These are older, more-familiar, components; they've always been applied with a big factor of safety, were relatively inexpensive, and the weight didn't matter. Costs were relatively low—and that was vital.

Not in a rocket, however. There every element represents ten times its own weight in fuel, so must be designed in for maximum service. And "reasonable reliability" is meaningless. The question is still "How reliable?" The buyer wants it to two decimal places, and costs must take second place, because economy in cost of a component is not an acceptable alibi when a rocket fails or when a jet liner crashes.

Thus we find engineers dusting off their knowledge of probabilities, talking of infant mortality, random failure, and wear-out as three stages measurable in operating hours. Some makers are protesting the cost of testing, but the requirement is spreading. We begin to find power-plant components, computer parts, and so on rated for reliability. Perhaps the ultimate solution will be cooperative test programs (even among competitors!) to spread the cost, but meeting the requirement had better be on the agenda.

Perhaps we will still continue to buy houses, cars, suits, foods and the other appurtenances of personal life on the basis of observation and the reputation of the maker, but not industrial components. There, sooner or later, the trademark and the reputation will have to be backed by some very reliable reliability numbers, with test results to prove them.

F. Haugrnan

these 3 steps choose a . . .

BATTERY-POWERED MOTOR

With an electric automobile for his example, author explains how product designer and motor manufacturer can cooperate to pick the dc motor that will best carry the load.

W M L ROGERS, *electric truck motor-design engineer*
Dc Motor and Generator Dept
General Electric, Erie, Penna

Any battery-operated motor, whether for cars, cranes, pumps, or an exotic Space Age application, must carry the load . . . but also conserve battery energy. This double goal accounts for three design steps needed:

1. Carefully determine load and duty cycle. For example, a motor-pump will have negligible load at low speeds, but power increases as cube of rpm. Also, a 5-ton crane with 250:1 gear ratio has much greater inertia in motor and gearing than in load; but the opposite is true for an electric automobile.

2. Specify a motor that has good efficiency where total energy requirements in load cycle are greatest. Such motors are usually custom-designed for the job. Efficiency can be predicted and planned by the motor manufacturer if he knows speed-torque requirements of load.

3. Match battery performance with that of motor and load. For example, a load with high starting torque needs a battery with high momentary discharge rate—with quick recovery to carry its normal full-speed load. Conversely, if load is effectively constant, matching is simple; this table gives constant motor output power that will discharge a 100-lb battery in 4 hr:

Battery (liquid electrolyte)	Typical capacity, w-hr/100 lb	Motor shaft hp (80% eff.)
Lead-acid	1400	0.38
Ni-Cd	1100	0.30
Ni-Fe (alkaline)	1200	0.32
Zn-silver peroxide	8000	2.14
Cd-silver peroxide	3300	0.89
Mg-silver chloride	1900	0.51

For faster discharge rates, battery capacity will be less. A lead-acid battery, for instance, will have only one-half capacity if discharge time is reduced to 30 minutes. (Watch for a coming article, "Batteries for Power," that will compare all commercial batteries under many different loading conditions.—Ed.)

SPECIFYING THE MOTOR

All dc motors have commutated armature windings, and may have one of several field designs: series, shunt, compound, or permanent-magnet. Shunt-wound are not used for battery operation.

Series motors are common where loads are heavy, because all current goes through armature and field, significantly raising power. They have high starting torque and can reach high speeds, but speed control is difficult because field is not separately adjustable.. Heavy loads lower speed considerably, yet torque—a function of current, and unaffected by voltage or speed—remains high. Series motors to about 20 hp are available.

Shunt windings lose some effectiveness when voltage drops, a poor characteristic when the power source is a battery.

Compound motors are usually designed with predominantly series characteristics; the shunt windings are used sparingly to improve speed control.

Both types—**compound and shunt**—are adaptable to dynamic braking.

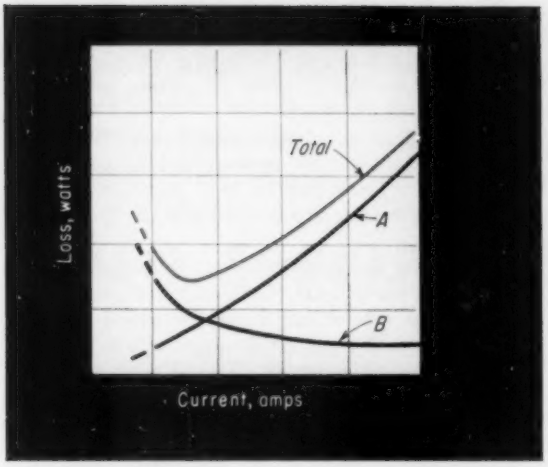
Permanent-magnet motors have inherently "fixed" shunt fields. Such motors develop high field strength, are small, and have improved efficiency because field windings are eliminated. But speed control is only fair, torque/current ratio is low, magnets are expensive, and armature windings must be carefully skewed to prevent cogging.

To select best motor for the job, trial-and-error calculations of performance for each under the given load conditions should be made by the motor designer. He can manipulate such variables as gear-reduction ratio, motor speed and torque to give lowest over-all losses for the intended operating cycle.

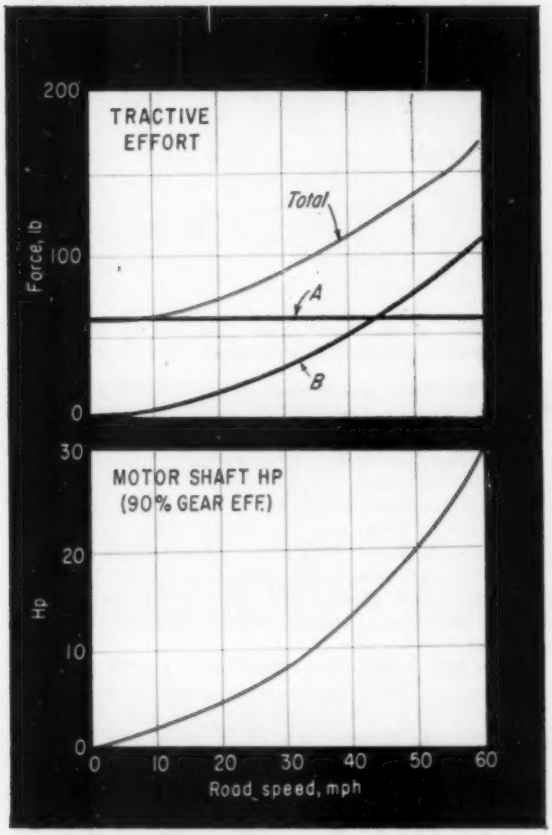
Things to consider are:

Motor losses at low loads and high speeds are mostly windage and friction. At high loads, electrical losses predominate. Proper design will place operating speed close to point of lowest total losses.

Conductor-cable and motor-winding losses increase as square of current. And because battery motors are normally low-voltage (24, 36, 48, 60, 72 and 80 v), the currents are high for a given power. For example, 400-amp current through a cable with 0.01-ohm resistance has a voltage drop = (400) × (0.01) = 4 v. This power



Total losses . . .
in a series motor are electrical, curve A, plus mechanical, B (from air friction, etc.) and show U-shaped curve when battery potential is constant. Note that motor speed drops with load, so motor should be designed to operate slightly to right of lowest-loss point—this gives margin for good part-load efficiency.



Motor shaft horsepower . . .
at constant speed on level road for a 3000-lb car is derived from tractive effort needed. Total effort, lb, assumes rolling resistance factor, A of 0.02 lb/lb and wind-resistance factor, B of 0.12 lb/(sqft-mph^2).

loss is about 8%, assuming a 48-v supply. Also, electrical resistance of copper wire increases about 20% with a temperature rise of 100 F. To predict performance, heat-dissipating characteristics of motor and enclosure must be known.

Motor deterioration—hastened by temperature or contamination—will spoil performance. Overheating can melt balance solder (if used), increase brush wear, and injure insulation and lubricants. Keeping the motor interior clean will help, but an enclosed motor, aircooled, will maintain original performance longer.

BATTERY-DRIVEN CAR

Here is an example of the 3-step motor-selection procedure. Assume a full-size, battery-driven automobile that weighs 3000 lb (including full load of passengers and luggage).

Step 1—Duty Cycle

Maximum road speed, hill-climbing rate, and range in miles are the major challenges. The first two—speed and climb—can be directly referred to motor rpm and torque by simple relationships:

$$\bullet\ \text{Motor rpm} = \frac{\text{road speed, mph, } \times 88 \times \text{gear ratio}}{\pi \times \text{wheel dia, ft}}$$

$$\text{where gear ratio} = \frac{\text{motor rpm}}{\text{wheel rpm}}$$

$$\bullet\ \text{Motor torque, ft-lb, } = \frac{\text{tractive effort, lb} \times \text{wheel dia, ft}}{2 \times \text{gear ratio} \times \text{gear eff, \%}}$$

$$\bullet\ \text{Motor shaft hp} = \frac{\text{tractive effort} \times \text{mph} \times 88}{2\pi \times \text{gear eff} \times 5250}$$

Tractive effort, lb, measured parallel to direction of travel, is the sum of rolling resistance, wind resistance, grade force vector, and acceleration force. Gear efficiencies run from 85 to 95%.

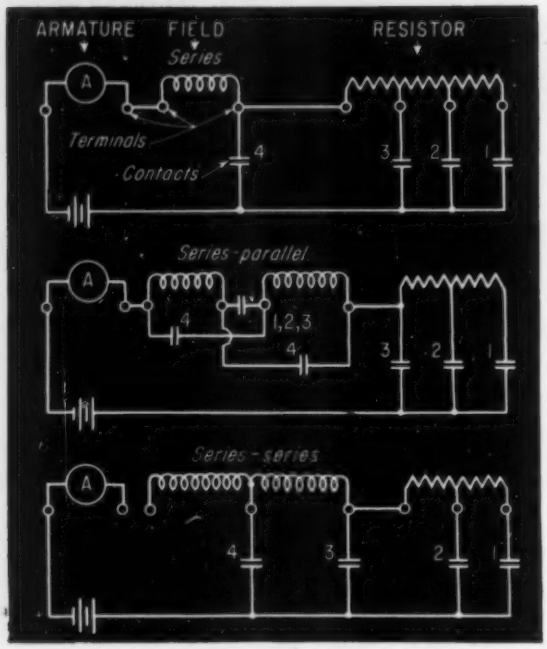
Rolling resistance depends on road roughness, tire deflection, tread design, loading and other factors. Resistance is less on grades, because effective weight normal to road is factored by the cosine of the grade angle (factor is 0.995 for 10% grade). Except for high speeds that centrifugally deform the tire, rolling resistance on level roads stays fairly constant.

To measure rolling resistance, tow the vehicle declutched at about 5 mph in one direction, and then in the other on a fairly level roadway and a calm day. The two-direction measurements compensate for slight slopes (grade of $\frac{1}{2}$% gives errors up to 25%). Typical values of rolling resistance are from 0.015 to 0.020 lb of resistance per lb of vehicle weight.

Wind resistance, lb = projected frontal area in sq ft $\times$ square of road speed in mph $\times$ wind-resistance factor. Frontal area can be assumed = 0.9 $\times$ width $\times$ height; resistance factor depends on aerodynamic design, and will vary from 0.1 $\times$ 10^{-3} for low, smooth designs, to 0.25 $\times$ 10^{-3} for box-type truck bodies. A headwind that is 20 to 30% of car speed during normal driving can increase power requirements over 40%.

To measure wind resistance, tow car as above on calm day, and use long cable. Subtract rolling resistance.

Typical Starting Circuits for Series Motors



Grade force vector (force to raise vehicle on grade), lb = vehicle weight x sin α, where α is grade angle. Note: % grade = tan α x 100. For small angles (less than 5°, tan α approximately equals sin α. When rolling resistance is 0.02 lb/lb, each 2% increase in grade increases motor load by amount equal to rolling resistance.

Acceleration force, lb = vehicle mass in slugs x acceleration, ft/sec^2. Neglecting motor and gearing inertia (not significant here) the energy required to accelerate a 3000-lb car to 60 mph is $\frac{1}{2} \times (3000/32.2) \times (88)^2 =$ 371,000 ft-lb; this = $3.766 \times 10^{-4} \times 371{,}000 =$ about 140 w-hr. Time to reach speed does not alter energy value, and the energy is not recoverable.

Step 2—Motor

One dc-motor type well suited for cars is the series-wound, 4-pole. It has high starting torque at relatively low currents, and can run at fairly high speeds (1500 to 4000 rpm, depending on design and duty expected). Above 2500 rpm, brush wear and windage may be problems. Although special "commutating windings" to reduce sparking are available, they are rarely used because battery potential will be low—about 48 v for car service.

Field and armature leads should be accessible so that controls can be attached. For starting circuits sketched above, contacts close in sequence (1, 2, 3, etc.), with number of steps optional. Since battery sections are separate, switching is possible from parallel (low-speed) to series (high-speed) operation. Additional resistance steps can be used in conjunction with motor windings to limit current and torque for smooth starts.

A motor rating of 15 hp for each rear wheel will carry a 3000-lb car 60 mph on a level road.

Step 3—Battery

Battery life in hours, or vehicle range in miles, cannot be predicted or related unless all speeds, grades, and other conditions are known.

Lowering speed on upgrades tends to conserve energy. Yet for a 10% grade, with speed reduced one-half, power is still about 3 times that for level operation. Wheel slip, an energy-waster, can be prevented by good speed control.

Running the motor as a generator on downgrades will return a little energy to the batteries but requires expensive additional controls and is not considered practical. The difficulty is that generated voltage will be low compared with battery potential. Special gearing to raise motor speed on downgrades will increase voltage; and parallel-battery circuits will help by lowering the charging potential needed. A third way is to add special shunt winding to increase magnetic flux during the period that the motor acts as generator, but saturation of magnetic structure occurs at relatively low potentials.

Only 2 or 3% of available energy can be returned to battery by any of the above means. This means that a 3000-lb vehicle on a 100-ft-high hill (300,000 ft-lb of potential energy) can recover about $0.03 \times 300{,}000 \times 3.766 \times 10^{-4} = 3.39$ w-hr of energy—an insignificant amount.

Batteries will be large. Even with level roadways, minimum tractive forces, 90%-efficient gears, 80%-efficient motor, and no acceleration losses, a lead-acid battery weighing 1000 lb can power a 3000-lb car for only 72 miles at about 18 mph. Then the battery must be recharged. One possible recharging scheme for long trips is to trade batteries—discharged ones for charged—at service stations. Short-distance and city driving are more practical: charging can be done overnight without removing batteries from car.

For REPRINT of above article, just check P14 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: These previous articles will background the author's 3-step procedure:

Determination of Motor Hp from Duty Cycle, Aug '50, p 131, develops the equation for root-mean-square hp, and applies it to several examples.

Driving High-inertia Loads, Apr '56 p 142, relates flywheel inertia to motor design.

Improved Dc Motor, Mar 31 '58, p 108, gives performance data on dc motor with compound-wound field that has armature control from 50 to 1500 rpm, and field control from 1500 to 6000 rpm. A 10-hp version drives vertical milling machine.

Here's Help in Selecting the Right Motor, Oct 13 '58, p 86, a bibliography listing several dozen articles in the past six years that cover ac and dc motors and applications.

Higher-energy Batteries, May 25 '59, p 46 and its sequel, **Those Higher-energy Batteries, a Practical Look,** Aug 31 '59, p 33, discuss all conceivable electrode pairs. Though many work in theory only, they indicate the range of possibilities.

The electric car has been reported previously in these news and development items: **Costs Force Electric Car Maker Overseas,** Aug 3 '59, p 23, explains problems faced by Stinson in producing new Charles Townabout; and **Electric Cars and Trucks,** Jan 26 '59, p 7, tells of proposed truck by Cleveland Vehicle Co.

Microscopes are replacing tensile testers for predicting service performance of cast irons. That's why this review of basic microstructures and how they affect design properties will help you make a better choice . . .

WHEN SPECIFYING A CAST IRON

W H MOORE, *vice-president, Meehanite Metal Corp.*

We have to consider more than tensile loading when judging a cast iron. As with other metals, performance can include such other conditions as impact, vibration, abrasive wear, thermal fatigue. Structure rather than tensile strength is therefore the more reliable indicator. But cast irons have many constituents that come in many forms. To make your specifications clearer, here is a practical guide to the microstructure of cast irons and how it influences service performance.

CARBON TELLS A STORY

Structure of a cast iron depends largely on the amount, size, and distribution of carbon in its various forms. The graphite form predominates and may exist in several shapes—most commonly as flakes. Usually one type and size of graphite predominates.

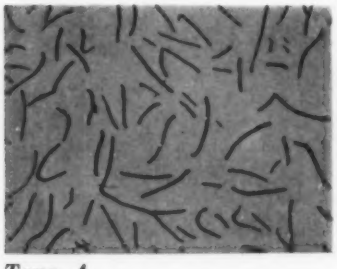
Most desirable is fine-flaked graphite with a uniform distribution (type A below) and random orientation. The irons are weakened when graphite flakes are thick and massive, as in C, or follow a solidification pattern, as in D. Specific graphites are better for specific service conditions. For example, types C or B are better in thermal shock—the carbon cushions stresses imposed by heating or cooling. Type D has some limited use where there is nonlubricated wear. Type A is best for structural service where higher strengths are desired and uniform properties required. In most high-strength cast irons some graphite will orientate itself to a type E pattern; if in large quantity this type indicates non-uniform structure and varying properties.

Graphite can range from size 1 (flakes 0.04 in. or longer) to size 8 (flakes 0.000,6 in. or less). Sizes 4 and 5, about midway, predominate in most engineering irons. With type A graphite in a pearlitic matrix, tensile strength ranges from 25,000 psi for size 1 to about 65,000 psi for size 8.

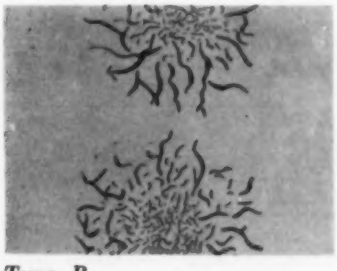
As flake size decreases, strength, toughness and Brinell hardness increase, machinability decreases, damping capacity decreases, and notch sensitivity increases. Small flakes give max density and pressure tightness; large ones, good machinability at fast cutting speeds.

Graphite as nodules (type F) gives high strength and

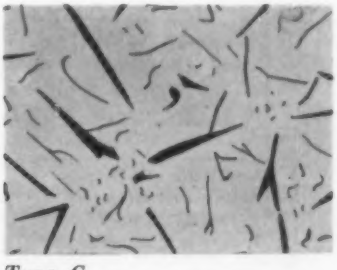
Graphite Distribution . . . 6 Basic Forms



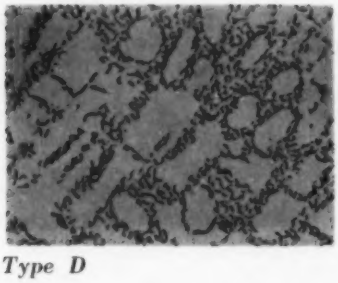
Type A



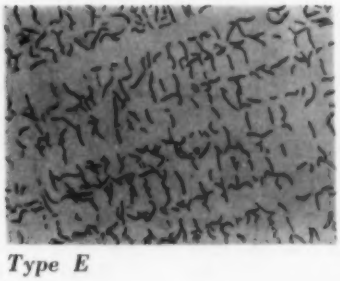
Type B



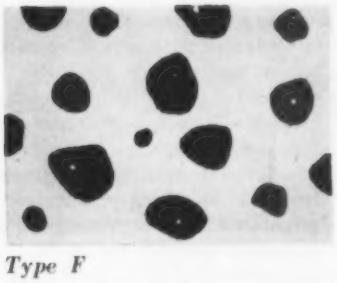
Type C



Type D



Type E



Type F

REPRINTED circle P13, inside back cover

MATCH THE MICROSTRUCTURE OF A CAST IRON TO THE APPLICATION

	PERFORMANCE DESIRED	MICROSTRUCTURE			ADDITIONAL SPECIFICATIONS NEEDED
		Graphite	Carbides	Matrix	
GENERAL ENGINEERING	**High strength** — good impact	Flake, type A	Nil	Pearlite Sorbite Acicular Tempered martensite	55,000 psi 60,000 65,000 70,000
		Nodular	Nil	Pearlite Sorbite Tempered martensite	80,000 psi 100,000 120,000
	High impact — good strength — moderate strength — low strength	Nodular	Nil	Ferrite 20% Ferrite Pearlite 80%	5-10% Elong. 15% Elong. 70,000 psi
	— damping capacity — notch insensitive	Flake	Nil	Acicular Sorbite	65,000 psi 60,000 psi
	Ductility	Nodular	Nil	Ferrite	15% Elong.
	Good machinability — low strength	Flake, types ABC	Nil	Ferrite	Total carbon, Hardness, min & max phosphorus
	— high strength	Flake, type A Nodular	Nil	Spher. pearlite Ferrite	Hardness Hardness
	High density — low porosity	Flake, type A	Nil	Pearlite	Max P and C
	Wear (metal-to-metal)	Flake, types AB	up to 10%	Pearlite Acicular	Min hardness Hardenability
	Magnetic permeability	Flake or nodular	Nil	Ferrite	—
WEAR RESISTANCE	**Machinable**	60% 100%	up to 40% up to 10%	Pearlite Martensite	Min & max hardness Heat treatment
	Nonmachinable: Abrasion — no impact	Nil	100% (massive)	Pearlite, Martensite	500 min Brinell
	— moderate impact	Nil	100%	Pearlite	Max tot. carbon, Max hardness
		Slight	100%	Martensite	Max hardness
	— high impact	Nodular	up to 10%	Martensite	Hardness
	— very high impact	Nodular	up to 5%	Austenite	Min % Elong., work hardening
CORROSION AND HEAT RESISTANCE	**Heat shock**	Flake, AB or C 100%	Nil	Ferrite Pearlite Austenite	Min tot. carbon Min tot. carbon Composition
	Continuous heat Low growth — above 1400 F — above 1700 F	Balance Flake, type A Nodular	30-40% up to 10% Nil	Pearlite Ferrite Ferrite	Composition High silicon High silicon
	Low scaling — above 1400 F — above 1700 F	Flake, type A Nodular	up to 10% up to 10%	Pearlite Pearlite	Silicon-chrome Silicon-chrome
	Moderate corrosion **Heavy corrosion**	Flake, type A Flake, type A	up to 10% Nil	Pearlite Austenite	Composition Composition

toughness, as well as ductility—but with loss in damping capacity and machinability. Size of the nodules is itself unimportant.

Chemical composition cannot alone predict structure or service performance. Though correct silicon and carbon content can give reasonably uniform graphite structure within one section, the cooling rate varies. Heavier sections will thus show coarser graphite, and lighter sections a finer graphite. The casting chemistry is usually a foundry responsibility, and foundry technique plays a large part in casting performance. This can be seen in graphitic ferrous castings. Here, for example, the Meehanite process gives close control of grain size—plus size and distribution of graphite flakes—thus permitting closer control property control. This is done by controls at three stages: charge makeup, the melting process, and graphitization after melt with alkaline earth materials.

WHAT ABOUT METAL MATRIX?

The iron itself is the second important factor that controls service performance. Most common matrix is pearlite—alternate layers of relatively soft ferrite and relatively hard iron carbide, producing a structure that resembles a fingerprint. This lamellar structure may be coarse, fine (sorbitic), or broken into small round shapes (spherodized).

Coarse pearlite machines better because it has a hard-

ness of about 190-200, compared with 250-270 for finer grades. Finer pearlite gives better wear as well as freedom from galling and seizing.

Sorbite-pearlite, too fine to be resolved under the microscope, is usually produced by heat treatment and is also called tempered martensite. It imparts excellent mechanical properties, particularly impact and tensile strengths, and machinable hardness. In nodular irons, sorbite can raise strength as much as 50%.

Spherodized pearlite, produced by annealing, reduces hardness and improves machinability without sacrificing mechanical properties.

Ferrite Irons

Next most common matrix, ferrite, resists oxidation very well because its silicon slows penetration of oxides from the outside. But ferrite-bearing irons are usually the softer, graphitic types with an open and weak structure. Still, an all-ferrite iron will not grow dimensionally above 1400 F, a problem with some pearlitic irons when the pearlite decomposes into graphite and ferrite.

Ferrite high in silicon is usually quite brittle and hard; the low-silicon ferrite machines easier. It is relatively ductile, but has higher tensile and modulus than the very low-silicon ferrite normally found in steels or malleable irons. In flake-graphite cast irons, annealing to get low-silicon ferrite is accompanied by a drop in hardness and strength. In nodular irons, ferrite formation is accompanied by a loss in hardness and strength, but an increase in ductility. This is why nodular irons requiring a definite elongation value are often specified with a ferritic matrix.

In general, applications for ferrite are confined to heat resistance and easy machinability. Where metal-to-metal wear is involved, ferrite has a much greater tendency to gall and seize than a pearlite. When ferrite is not required, its presence betrays poor cast-iron metallurgy.

Most cast irons with a high-strength graphite structure are usually free from ferrite, except for nodular types where ferrite is the rule rather than exception.

Other Matrixes

After ferrite and pearlite comes the martensite (acicular) matrix—a hard structure consisting of needles of carbide. It is produced by rapidly cooling the iron from above 1400 F down to room temperature—as occurs in oil or water quenching—to give high hardness. Martensite cooled somewhat slower (bainite) is usually coarser. Alloying both structures gives good mechanical properties and much higher strengths than with pearlite.

Fine bainite, in low carbon irons with excess carbon as carbide, has hardnesses up to 700 Brinell and good wear resistance. When excess carbon is nodular, the structure has a 450-650 Brinell, tensile strength above 60,000 psi, and relatively high impact value. It is useful where wear is abrasive type and service conditions require more toughness than normal in a white cast iron.

A recent example, an alloy called Almanite, uses Mn as an alloying constituent. This alloy, which can also be produced with the less common austenitic matrix, has a tensile strength of 100,000 psi, yield of 75,000 psi, and elongation more than 10%. It is very tough under impact and, although hardness is 220 Brinell, it gives difficulty by work-hardening during the machining operation—the austenite becomes wear-resistant martensite. Corrosion-resistant austenitic structures can also be produced by nickel alloying.

White Cast Irons

In the white cast irons, where excess carbon occurs as carbides, carbon content rather than form determines the physical characteristics. Thus, the white iron rich in hard carbides is harder and more brittle than when carbide content is low. But range of toughness here is limited. Greater range is possible by changing the matrix of white cast iron from pearlite to martensite. By combining low carbide content and a martensitic matix, one gets a reasonably tough and extremely hard-wearig cast iron. But specifying requires care because toughness is important in wear and only relatively low-carbon white irons will be reasonably tough. High-carbon white irons are useful only where purely abrasive conditions exist and no impact occurs.

WRITING THE SPECIFICATION

Cast-iron specifications can be misleading. A foundryman can produce cast iron to a certain chemistry and produce it to meet most physical-property requirements, but his process may not allow doing both. For best physical properties it's wise, therefore, to leave the chemistry up to the foundry—or, at most, specify min or max figures.

For example, if you want cast iron for thermal shock resistance, but no particular physical strength, best specify minimum carbon content of about 3.30%. This ensures sufficient graphite to give heat-shock resistance. Also, a min silicon content might be specified to give gray iron (for machinability) rather than white. Simplest is to specify no free carbides in the microstructure. This lets the foundry decide the procedure that will give free graphite instead of free carbides.

For high strength one might specify a max carbon content, hence min graphite. But this specification is total carbon rather than graphite content. It's better to specify a definite structure—such as a fully pearlitic iron with type "A" graphite content—along with max carbon content (see table, facing page).

Most complete specifications insist on a definite structure, and a certain range of physical properties when these are needed. They are: tensile strength and hardness, modulus of elasticity, endurance limit, and such factors as creep strength and coefficient of expansion, magnetic properties and density or specific gravity. It's best to write a specification that covers the average structure and combine this with at least one important physical property. A photomicrograph of the desired structure will often fix the structure more definitely, since more and more foundries now use microstructures as a routine standard.

For REPRINT of above article, just check P13 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: The following recent articles on casting processes cover recent developments and techniques:

Tight Tolerances Can Be Even Tighter, July 20 '59, p 49, shows how costs can be cut by using investment casting "as-is."

Investment Casting or Sintered Powder? June 8 '59, p 86, gives guideposts for picking the right process for small parts.

Forging Presses Strength into Lightweight Castings, Feb 16 '59, p 61; data explains how follow-up forging can improve parts cast from aluminum and magnesium alloys.

CLAY MODELS *will shape your ideas*

For a quick preview of design—and an appreciation of the production problems—fashion a clay mockup before you start the drawings. Modeling tools and materials are inexpensive; time and experience required is negligible.

Casting, courtesy: Simmonds Aerocesries Inc, Tarrytown, NY

JOS F REIS, *Pres*
Reis Associates, Tarrytown, N Y

The model shown above (at left) was roughed out of a block of clay in a little less than 10 minutes. The surfaces aren't smooth and the lines aren't straight but it gave the designer what he wanted: an opportunity to look over the proposed casting from every angle before he sat down to design it.

Clay models are also useful at other design stages. If, for example, a part fails under test, a little clay can be added to the weak section to represent the reinforcing structure while insuring that necessary clearances are maintained. Other times, the model can serve as a sales tool, giving salesmen and their customers a clear look at the proposed design.

Tools and materials

Art supply stores will have everything you need. Clay in blocks of 1, 2, 5 and 50 pounds, can be purchased in almost any color. Prices range from 30 cents to $1 per pound depending on quality. There are two kinds: air-drying (or self-hardening) and non-hardening (the so-called "plastic" clay). Plastic clays are easier to work with but, because they never lose their putty-like consistency, are not suitable for certain applications.

Another modeling material, "SCULP-Metal," is useful for special jobs. From the modeler's standpoint, it is very similar to the air-drying clay except that the hardened form is a metallic substance that can be machined. As with air-drying clay, if proper draft is provided it can be used as a pattern for a preliminary casting.

Only a few simple tools are needed to get started. A short-bladed knife is the most important. It is particularly helpful for removing large portions of clay in the initial modeling stages. Also be sure to include several sizes and shapes of "wire-end" tools (simply a small loop of wire attached to a handle). They are handy for detailing, and will remove small amounts of material quickly and easily, leaving a smooth surface.

Shaping the material

Remember that what you are after is the general shape of the part, not a detailed model. The size chosen should be neither so big that it takes long to mold, nor so small that you cannot indicate necessary detail.

Place one or more blocks of clay on a suitable base—a sheet of plywood, aluminum, or glass plate will serve. With the knife, sketch the top, side, and plan views of the part on the flat surfaces of the block, then cut away all excess material. Don't be afraid of cutting away too much; you can always put it back again. Now, with your fingers, mold the part to the desired contours and add detail with the knife and wire-end tools.

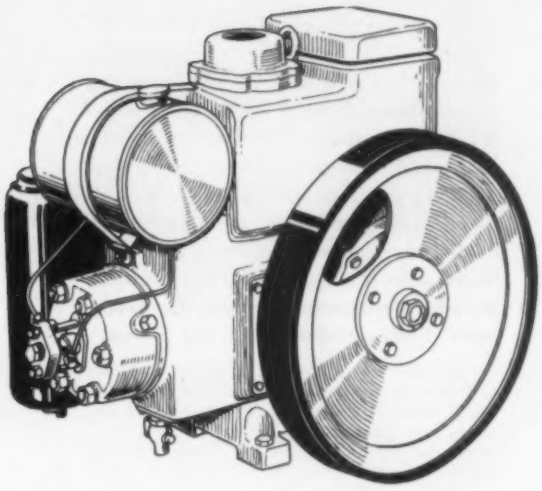
Some free-standing forms will require internal bracing. When the model is expected to have large unsupported masses, this "armature" should be made before beginning to work with the clay. Two pieces of wire, twisted together to give the clay something to cling to, can be bent and twisted to form the outline of the piece. Clay is added in balls, a little at a time, until the armature is covered and the desired shape is formed.

Armatures should be avoided wherever possible, however, because they limit the amount of clay that can be removed. A better reinforcement is insertion of wooden splints wherever there are weak parts that need to be made more rigid. These can be made from tongue depressors split into strips of the proper width.

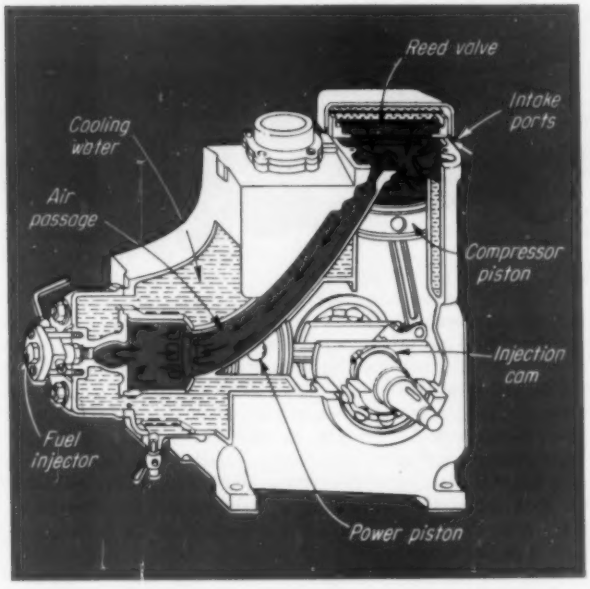
Air-drying clay should be used when accurate models are needed. It is handled the same way as the plastic clay but must be covered with a wet cloth when not in use. After the model is completed and has dried, it is finished with file or scraper to exact dimensions. A final tip: air-drying clay shrinks when it dries, so be sure to allow enough extra material to file away. ■

One Cylinder Boosts the Other

In this diesel, supercharging effect of compressed intake air doubles power output and provides positive scavenging. Adjustable cam allows accurate setting of fuel injection.

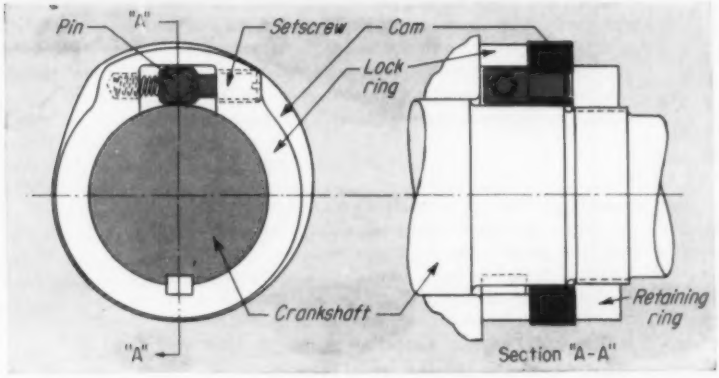


Stationary diesel engine of 926-cc (56.5 cu in.) displacement produces 9.87 hp at 950 rpm—claimed to be double the output of comparable diesels. The engine is produced by Ebbs and Radinger, Vienna, Austria.



The two cylinders . . .
are at a 90° angle to each other; the power cylinder horizontal, the air-compression cylinder vertical. Connecting rod of compression cylinder is linked to bearing cap of the power-cylinder connecting rod. Larger bore and longer stroke of the compression cylinder provide double the volume of air needed for the power cylinder.

Air through the intake ports passes through an air filter and a reed-type checkvalve as the compression piston descends. On the power stroke the compression piston rises, forcing air through the air passage into the power cylinder. The entering air scavenges the burnt exhaust gases and fills the power cylinder with compressed air. This is the supercharging effect that increases output.



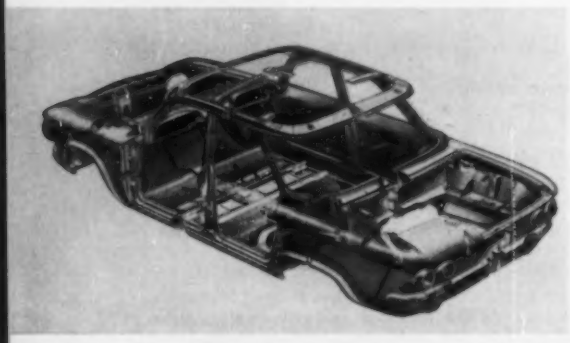
Fuel-injection timing . . .
is set by adjustable cam mounted on the crankshaft. The cam assembly consists of a lock ring, cam and retaining ring. The lock ring is keyed to the crankshaft. The cam, which operates the injection pump, slips over the crankshaft and is free to move. A steel dowel in the cam fits into a recess in the lock ring and is positioned by a spring and setscrew. By turning the setscrew, precise adjustment of the fuel-injection timing cam is possible.

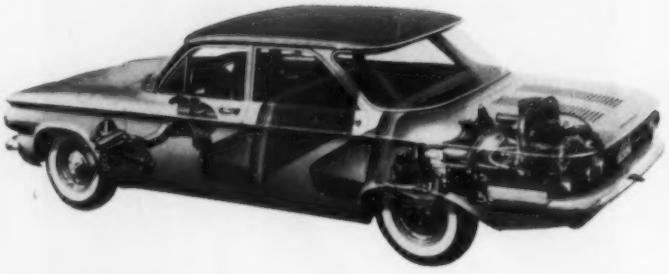
PRODUCT DESIGNS: SECOND OF THE BIG THREE'S

CHEVROLET'S

Here it is—the Chevy whose designers moved the engine from front to rear. It's General Motors' entry in the race to give American motorists something cheaper, smaller and really new. The 6-cyl power plant is aluminum, air-cooled, horizontally opposed, and combined with a trans-axle. Other features include preassembled suspension packages, body integral with the frame.

Corvair represents a complete departure from current US carmaking practice. Dimensionally, it's practically identical with Ford's Falcon; mechanically, there's little basis for comparison. Corvair's debut follows that of Falcon *(PE—Sep 28, p 58)*; the third of the three rivals, Chrysler's Valiant, will be described mechanically in the next Design issue. Corvair comes with either manual or automatic transmission.



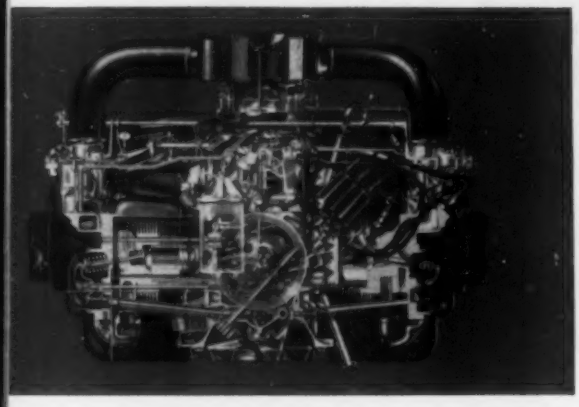


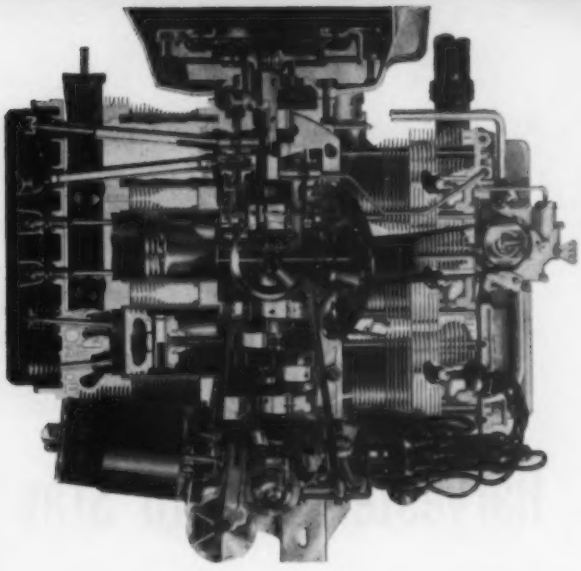
Coil-spring suspension . . .▲
is independent at all four wheels. Front and rear suspension components are mounted on box-section cross-members that are preassembled and attached to the completed body. Upper A-frames of the front upper suspension are steel stampings with rubber-bushed mounting shafts. The front lower A-frames are 2-piece units—stamped beam and bar strut. This beam incorporates a coil-spring seat in the middle and a ball-joint mounting flange at outer end. The strut is bolted to the beam and angles rearward to a rubber-bushed mounting. Inner end of the strut is threaded; varying the effective length of the strut adjusts the front-wheel caster angle.

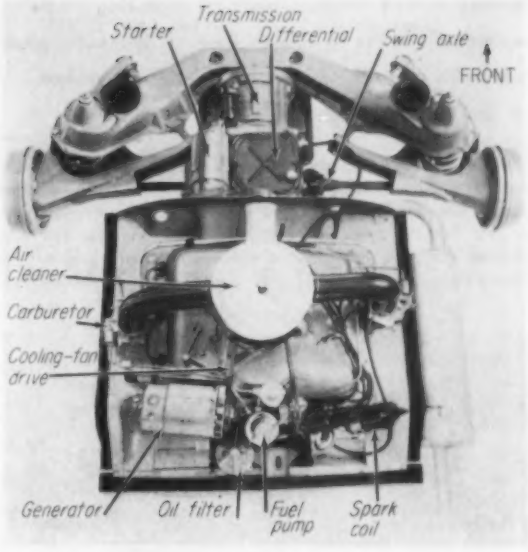
Rear suspension has semi-trailing control-arms that support the wheel bearings and brake backing-plates, and mount the coil springs and shock absorbers. Angular mounting of the control arms causes their projected pivot axis to pass through the swing-axle universal joints. This holds angular deviation between swing axle and control arms to a minimum. Toe-in of the rear axle is adjustable by shimming the transmission mounts in front and the engine mount in the rear, fore and aft, as required.

All-welded body . . .
incorporates an integral frame of box-section reinforcements on the underbody. Instead of the usual driveline tunnel, Corvair has a shallow rise providing a protected area for controls to the engine and transmission. Above its sill level, the body construction follows standard practice with box-section front, rear and side pillars welded to the roof rails. Luggage- and engine-compartment lids are dual-panel type, with baffles mounted under compartment lid engine louvers to drain off water. On engine side the panel between engine and rear seat is insulated by a 1-in.-thick blanket of fiberglass covered with polyethelene facing. On the seat side a $\frac{3}{8}$-in.-thick jute blanket and hardboard completes the insulation. Luggage compartment is at front, and contains the gasoline heater and spare tire.

CORVAIR







Horizontally opposed engine . . . is mated to the trans-axle, consisting of differential and transmission, at its forward end and assembled with the rear-suspension cross-member and swing axles before installation in the body. Entire engine is encased in a sheetmetal shroud that forms a plenum chamber and encloses the horizontally mounted centrifugal blower. Air entering the shroud directly under the air cleaner is forced past finned cylinders and cylinder heads into a duct under each bank and discharged beneath the car at rear of the engine. Airflow is controlled by a bellows thermostat in the base of the plenum chamber, which closes the air intake until the engine reaches operating temperature.

Two carburetors receive air from the single air cleaner. They are connected to the cleaner by large-dia elbows and mount directly on the intake manifold cast into the cylinder head. An automatic choke mechanism controls a butterfly valve on the air-inlet pipe, instead of the carburetors themselves.

Central structural member of the engine is the rectangular aluminum alloy crankcase. The 2-piece crankcase is bolted together at the vertical parting line. A steel oil pan is bolted to the bottom and an aluminum crankcase cover closes the top. Besides closing the rear end of the engine, rear housing contains the oil pump and some of the primary oil passages, also provides mounting for distributor, fuel pump, oil filler pipe and rear-crankshaft oil seal.

Each crankcase-half has three openings on its side into which individual cast-iron cylinders are spigoted. Each set of three cylinders shares a common cast-aluminum cylinder head which contains the intake and exhaust valves. Hollow pushrods, operated by hydraulic valve lifters, conduct lubricating oil to the stamped rocker arms. The pushrod tubes serve to conduct oil back to the oil pan. Twelve long studs, four per cylinder, retain each cylinder head.

The crankshaft runs in steel-backed babbit-lined main bearings mounted directly in the crankcase webs. Fitting directly into the crankcase at junction of the two valves, the bearings become left and right halves, instead of upper and lower. The camshaft is mounted directly below the crankshaft and runs in bearing surfaces machined directly in the crankcase casting without bearing inserts.

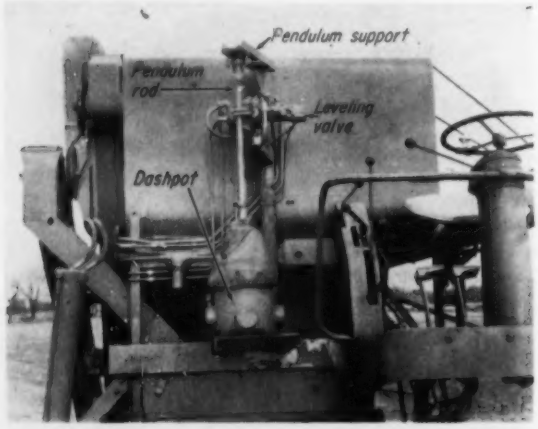
QUICK LOOK AT CORVAIR'S 4-DOOR SEDAN

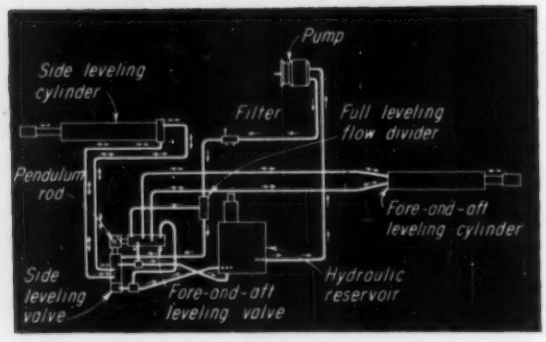
Over-all length	180.0 in.
Over-all height	51.3 in.
Over-all width	66.9 in.
Weight (dry)	2305 lb
Wheel base	108.0 in.
Tread, front	54.0 in.
rear	54.0 in.
No. of cylinders	6
Bore & stroke	3.375 x 2.60 in.
Displacement	140.0 cu in.
Compression ratio	8.0 to 1
Torque, lb-ft	125 @ 2400
Brake-horsepower	80 @ 4400
Tire size—tubeless	6.50 x 13
Brake area	120.8 sq in.
Turning dia	39.0 ft
Water capacity	(air cooled)
Electrical system	12 volts
Fuel-tank capacity	11 gal.

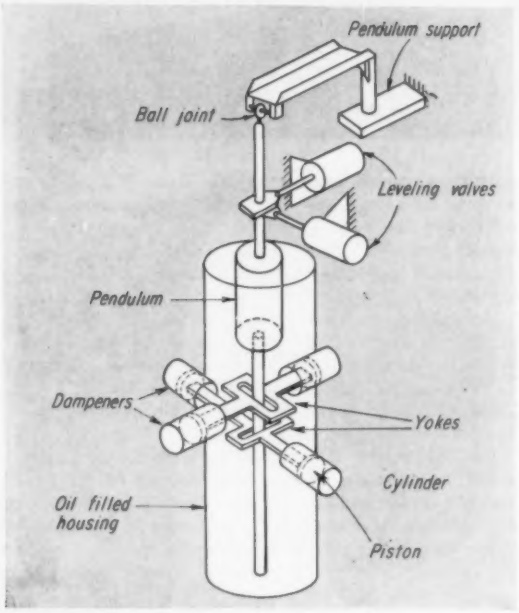
Harvester Tilts to Stay on the Level

Its wheels follow slope of a hill but operating portion of this combine goes on digesting crops normally—thanks to orders from a hydraulic plumb bob. Oil also dampens any erratic movements of the control pendulum.

The one-man combine answers hillside problems when reaping barley, sorghum, oats, rye, soybeans, wheat. While cutting and threshing, it blows chaff to the rear and stores grain in a hopper for discharge to a moving truck. Hillside Harvester-thresher No. 151 is produced by International Harvester Co, Chicago.







The pendulum's job . . .

is to serve as vertical reference line and actuator that levels the combine platform no matter whether a hill goes up and down, or sideways. Two leveling valves connected to the pendulum-suspension rod are activated when the combine tilts. Oil pressure through these valves is directed to the appropriate leveling cylinder. This cylinder then levels the work surfaces, centers the pendulum, and closes the leveling valves.

Four pistons, in an oil-filled dashpot below the pendulum bob, provide damping in two planes. They are worked by an extension of the pendulum rod, which swings with the bob. Simple yokes allow the pendulum assembly to move in any direction and provide proportional displacement of both leveling valves for various tilt conditions.

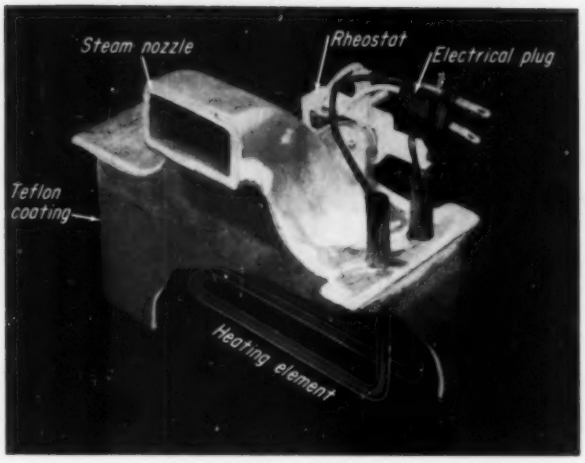
◀ **Hydraulic power . . .**

for leveling is provided by engine-driven pump supplied from a central reservoir. Displaced pendulum rod moves the leveling valves to actuate the leveling cylinders. When thresher platform is leveled, pendulum is centered and valves closed.

Non-clog Humidifier Runs on Furnace Current

Electrical unit puts steam into the warm-air system and doesn't leave clogging residues behind . . . uses noncorrosive materials to discourage buildup of scale deposits.

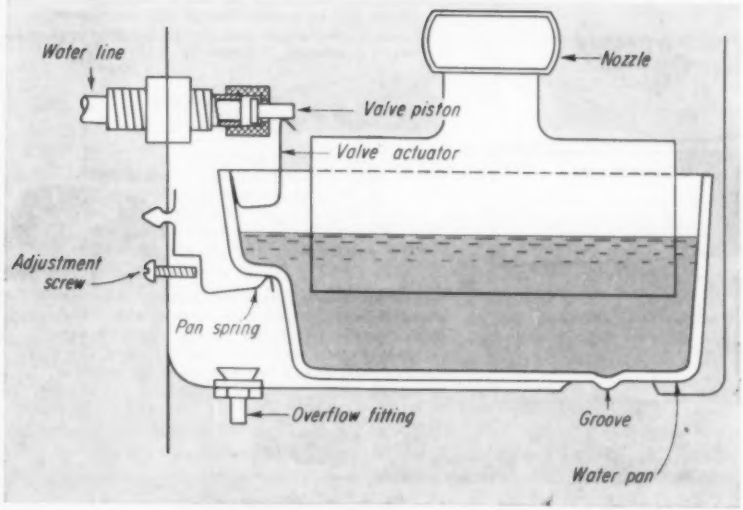
Humidifiers for home-furnace applications usually depend on asbestos plates to supply moisture by evaporation. But the plates need frequent replacement because mineral deposits build up and choke off evaporation. With this electric unit, maximum delivery is 5 gals. of water distilled into the warm air per 24-hr period. Viking "4200" Electric Humidifier is produced by Viking Air Products, Cleveland.



Steam unit . . .

is mounted on the furnace, with its cast-aluminum steam nozzle projecting into the plenum chamber. Heating element cast in the nozzle is submerged in the water and wired to the blower-motor circuit. When blower goes on, heating element boils water in pan, discharging steam through nozzle.

Cast nozzle is sprayed with Teflon and baked at 700 F to provide a non-sticking inert surface that resists mineral deposits. Electrical plug provides quick disconnect to enable pan and nozzle to be removed for cleaning. Rheostat provides adjustment for desired rate of water evaporation. The ceramic has a glazed surface highly resistant to line adhesion.



Humidifier supply . . .

water is held at a constant level. Water pan is tilted upward by the pan spring when level falls. When pan rises, valve actuator deflects the valve piston, admitting water. Nylon valve shuts off water when pan weight overcomes force of pan spring, and pan returns to level. Self-closing valve uses water pressure to provide tight seal.

MAGNESIUM-LITHIUM...

new contender for lightweight champion

This series of magnesium alloys with an even lighter alloying agent offers 25% weight saving over conventional Mg alloys. Here are first property data.

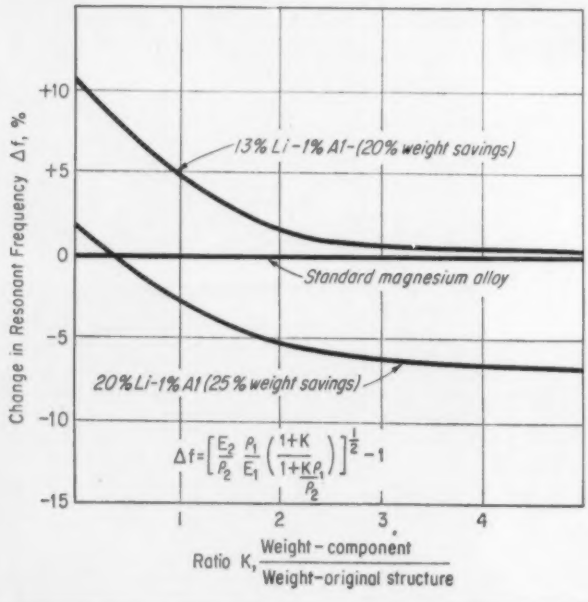
DAVID F CALDWELL,
Light Military Electronics Dept
General Electric Co

Large weight reductions are promised by a new family of magnesium alloys. These extreme lightweights, only ¾ as heavy as magnesium itself, are made by teaming up lightweight magnesium with the still lighter lithium which is only ½ as dense as water. These first Mg-Li alloys contain small amounts of aluminum to enhance mechanical strength at a little sacrifice in weight. Unit tensile properties are not high but strength per unit weight is equivalent to or better than the standard Mg alloys used for such structural parts as electronic gear cases, covers and instrument panels.

Tensile data are given in the table. To date, most of the development has been on alloys with 13 to 15% Li and 1 to 6% Al. Tensile properties that can be consistently achieved for these alloys in hot rolled condition are: ultimate strength of 26,000 psi, yield strength of 20,000 psi, with 10% elongation. Extruded materials are more ductile and show about 25% more elongation than the rolled material.

High-strength Possibilities

As cast, the Mg-Li alloys have ultimate strengths in the range 50,000 to 60,000 psi. However, strength drops off with time and within 2 weeks falls to the more stable values shown in the table. If a way could be found to retain this initial as-cast strength, these alloys would have much broader application. One technique–solution heat treat at 500 F and quench–gives a compressive yield strength of about 65,000 psi. But this treatment makes the alloys very brittle with ductility in tension too low for forming. Aging this quenched alloy at 180 F increases ductility but also lowers strength.



How the Material Can Change Resonant Frequency

Assuming the structure is a series of uniformly loaded flat plates and rectangular beams with components that add to the weight but not to the structural stiffness, the resonant frequency is:

$$f = A\sqrt{\frac{E}{\rho}\left(\frac{Wc}{Ws+Wc}\right)}$$

where: f is resonant frequency
A is the constant due to the shape
E is the elastic modulus
ρ is the density of the material
Wc is the weight of the components
Ws is the weight of the structure

Formula for change in resonant frequency shows that largest change is achieved for material with a high elastic modulus and a low density. Ratio of component-to-structure weight becomes important where the component load is less than twice the weight of the structure.

How Mg-Li Compares with Standard Magnesium Alloy

% Alloy in Mg	Density, lb/cu in.	Young's Modulus, psi x 10^6	Ultimate Tensile, psi	Yield, psi
3 Al (Std.)....	0.0648	6.5	43,034	35,100
13 Li-1 Al.....	0.0506	6.5	22,940	21,730
13 Li-3 Al.....	0.0521	6.5	25,200	21,800
13 Li-6 Al.....	0.0518	6.5	36,560	34,700
15 Li-1½ Al....	0.0502	6.3	27,350	25,667
15 Li-3 Al.....	0.0506	5.6	24,840	23,080
20 Li-1 Al.....	0.0467	5.2	16,870	13,080
20 Li-3 Al.....	0.0471	5.7	26,130	23,490

Elevated-temperature Limitations

Tensile strengths of these first alloys decrease slightly with rise in temperature, dropping off more rapidly above 150 F. Therefore parts should be adequately cooled or insulated if temperatures much above 150 F are expected. While this temperature limitation is severe, it is still within the present-day working range of many electrical and electronic components.

Because the melting range, about 1000 to 1100 F, is close to the melting range of the aluminum and magnesium alloys it is likely that other alloys can be developed that retain their strength at 400 to 600 F—present limits for aluminum and magnesium.

Vibration Control

The Mg-Li alloys compare favorably in resonance with the standard Mg alloys. Some change in resonant frequency (up to 10%) can be obtained as illustrated in chart, facing page, by simply substituting certain Mg-Li alloys for Mg counterparts. This frequency shift may be helpful in reducing vibration stresses where standard magnesium or aluminum parts in a structure have a resonant frequency within the critical range. This is particularly useful in missile applications.

Fabrication and Welding

In general, the Mg-Li alloys are even easier to machine than magnesium. They are also easily welded where sections are less than 1 in. (heavier plates have not yet been welded successfully). The alloys are easily workable at room temperature, and formable almost without limitation when heated to 400 F. As for all Mg alloys, care is necessary to prevent ignition. The Li in these alloys make them somewhat more active; they combine both with water and sand to form hydroxides and silicates.

Corrosion Protection

Standard passivating treatments plus primer and paint as used for magnesium have not been successful for Mg-Li. The standard coating when exposed to salt spray protected the material except that the coating peeled excessively at scratches where metal was exposed. Best coating method so far: One coat of wash primer, followed by a primer, and two coats of vinyl topcoat. This combination, where tested in salt spray, prevented corrosion from undercutting the coating even when scratched through to the bare metal.

Castings from Mg-Li do not seem to be immediately imminent; the metal is too active chemically for casting by normal green or dry sand methods. The newer techniques now commonly used for reactive metals—vacuum melting and pouring into chilled metal molds—show the best possibilities for casting Mg-Li alloys.

EDITOR'S NOTE: For information on the availability of these new alloys, write to the following concerns: Brooks and Perkins Inc, Detroit; Dow Metal Products Co, Midland, Mich; Lithium Corporation of America Inc, Minneapolis. Other recent articles on the lightweight standard—the magnesium base alloys and how to design with them:

Pellet Extrusions Beef Up Magnesium Structures, May 12 '58, p 80, tells how their high compressive strengths promise radical changes in design of large magnesium sections.

Magnesium Castings can be Welded without Distortion, Sept 16 '57, p 94, describes salvage process adapted to permit welding-in minor design changes; welding technique eliminating preheat avoids distortion.

Magnesium Alloy Treatments, Mid-Sept '58, p C4, compares in handy chart form, protective finishes for magnesium alloys.

For desk and drawing board

this will save DESIGN-TIME *and* WORK

Its name is *Product Engineering Design Manual.* The book is a guide to quicker, easier solutions of the engineering design problems likely to arise in your everyday work. It offers a ready-made file of illustrated methods, devices, formulas, tables and charts.

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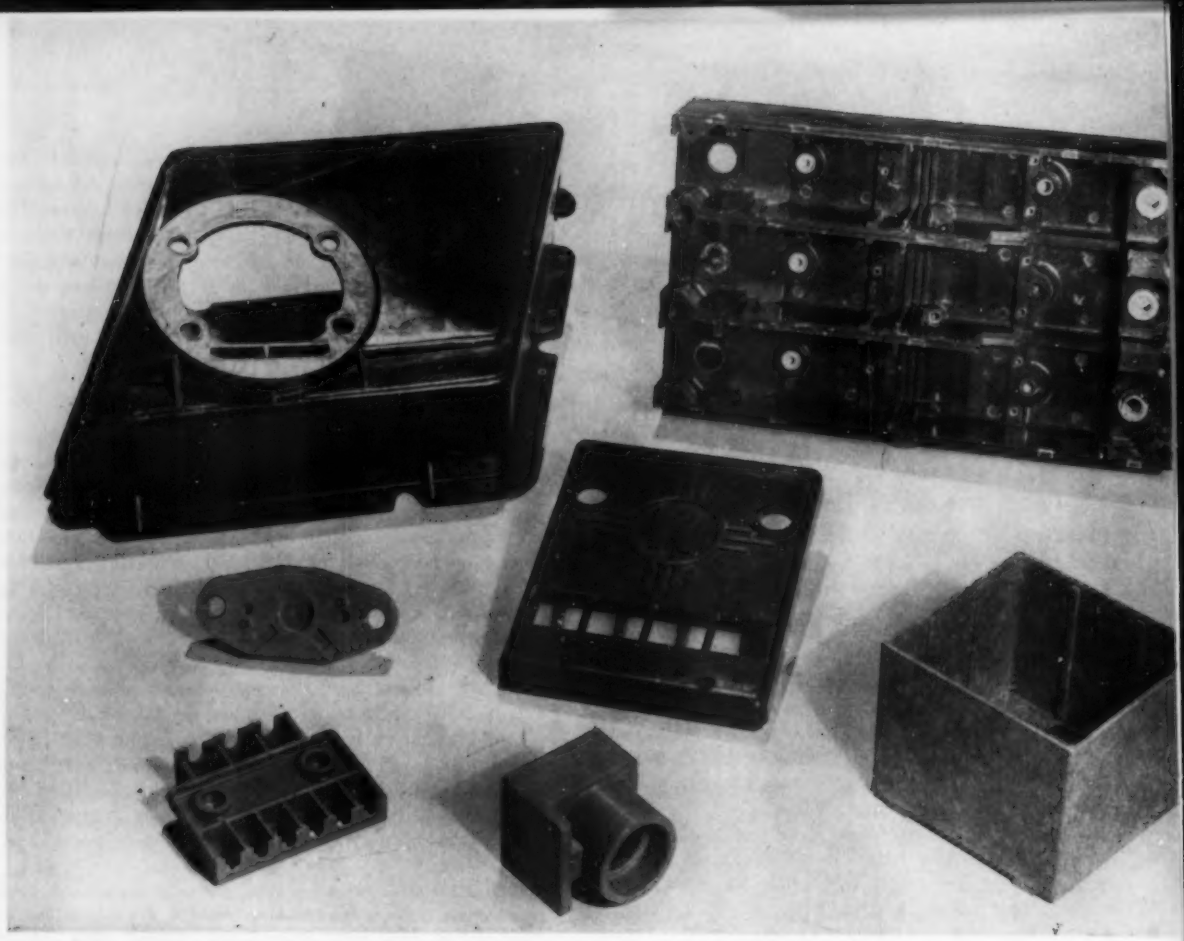
PRODUCT ENGINEERING DESIGN MANUAL, by Douglas Greenwood, Associate Editor. 340 Pages, 8½ x 11. McGraw-Hill Book Co Inc, 330 W. 42nd St., New York 36. $9.



design must be different for

POLYESTER PREMIX MOLDED PARTS

They can be substituted advantageously for metal in many applications. But design has to follow somewhat different ground rules than for unreinforced plastics.

R F DOYNE, *director, Plastics Technical Service*
S S FEUER, *development supervisor*
Atlas Powder Co, Wilmington, Del.

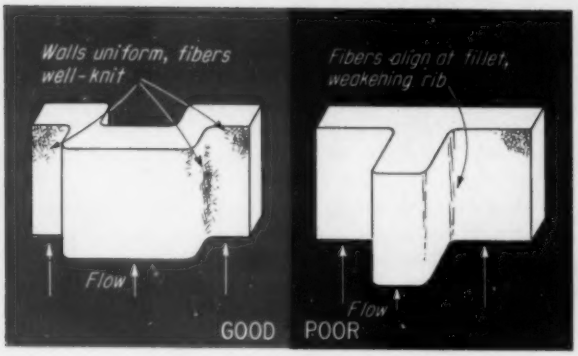
Those beefed-up plastics, the polyester premixes, are moving into many structural applications traditionally dominated by metals—for example, large housings, appliance frames, pump parts, and chassis for electric equipment (typified by the above moldings). This is partly because the premixes are easily moldable for large parts, partly because they offer the highest impact and flexural strengths, coupled with rigidity, of any high-speed molding material. Such advantages outweigh the present limitations: modest tensile strength, a tendency toward surface rippling, some nonuniformity of glass dispersion.

But substituting premix for metal requires thinking ahead. Money can be saved only when the premix balance of properties is just right. More important, the part must be carefully redesigned in terms of premix capabilities.

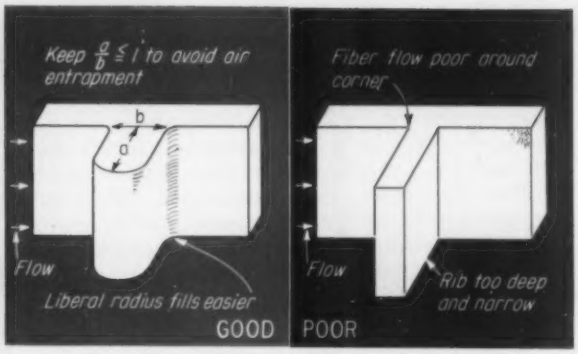
Glass Fibers Influence Design

It is the chopped glass fibers mixed into these resins that provide strength and rigidity. And varying the glass content in the semicured compounds will sharply change their mechanical properties, as shown in the accompany-

HOW PREMIX FLOW INFLUENCES RIB DESIGN



I: Flow Parallel to Rib



II: Flow Perpendicular to Rib

ing table. Premixes should therefore be considered a family of plastics with three main, overlapping categories—depending on glass content. These are also commonly called low-, medium-, and high-impact groups, but impact strength range of the so-called "low" group is well above the range of 1 to 2 ft-lb/in. usually associated with "medium"-impact unreinforced plastics. Hence glass content is the better criterion.

The glass fibers are also what make the molding process—and hence the design problems—different from working with unreinforced plastics. The part must be so designed that, during the compression- or transfer-molding cycle, the compound will move smoothly into all parts of the cavity, and each critical area will receive its fair share of fibers. These are design factors influenced by the addition of glass:

Fillet radii require more attention here than with phenolics or melamines because the fibers do not flow easily around sharp corners. If there is a long flow in the mold, attended by several changes in direction, fillet radii should be $\frac{1}{4}$ in. or more. For short flows, this may be cut to $\frac{1}{8}$ in., or less in special cases. If stress concentration is unimportant, square edges and corners are no problem. In fact, a current method of low-cost mold manufacture builds the mold in sections—producing sharp corners automatically. External edges are usually broken to $\frac{1}{32}$-in. radius to avoid chipping.

Stiffeners like ribs, bosses, and gussets—common in molding—can cause trouble with premix parts unless simple rules regarding flow direction are observed, as shown in the accompanying sketches. For ribs, the best general rule is: keep them at right angles to the plastic flow. When flow is along the rib, the plastic-glass mix moves more rapidly in the rib than in the wall because the area is larger. Thus the fibers tend to align themselves along the fillet, and weaken rather than strengthen the juncture of rib and wall. Tearing along the fillet during the molding cycle or during service can result when random orientation of fibers is upset in this manner.

Keeping ribs across the plastic-flow direction illustrates a basic principle: Strength in premix parts comes from random cross-knitting caused by tumbling of the mix as it moves through the mold. Design that promotes such action is good. Another example is bead-stiffening of edges, flanges, or rims less than $\frac{1}{8}$ in. thick. Such beads should always be thicker than the wall being stiffened,

WHAT ARE PREMIX COMPOUNDS?

The polyester premixes are a combination of reinforcement, pigment, filler and polyester resin—with proportions and type of each ingredient determined by characteristics required in the final product. Glass is the most common reinforcement (fibers, $\frac{1}{4}$ to $1\frac{1}{2}$ in. long), but much sisal is used, and asbestos fibers are gaining popularity.

When delivered to the molder, the premix is putty-like and can be either compression- or transfer-molded at relatively low temperatures and pressures. For compression molding, 275 to 350 F and pressures in the order of 400 to 800 psi are recommended. Slightly higher pressures are needed for transfer molding.

These polyester premixes use about the same compression- or transfer-molding techniques as do the very common phenolic or melamine compounds. Main difference: the premix materials carry individual strands of reinforcement. Design must therefore give the part as uniform a distribution of the reinforcing fibers as possible.

Mechanical Properties of Typical Premix Materials

Property	Polyester & Sisal	Polyester & Glass			Phenolic, glass-filled	Mat or Preform Molding
		Low glass (<10%)	Medium glass (10-20%)	High glass (>20%)		
Izod impact, ft-lb/in.	1-2	2-3	3-6	6-15	8-10	15
Flexure strength, psi x 1000	6-8	7-10	9-14	12-19	13-16	25
Flexure modulus, psi x 10^6	0.9-1.2	1-1.3	1.3-1.5	1.3-1.8	1.7	1.5

preferably twice that thickness. Wise use of ribs and beads in this manner helps premix parts lower costs over cast and diecast metal parts.

Holes can be molded, punched, or drilled. The main problem with molding, by far the cheapest way, is placing holes too near edge of the part—at least ¼ in. away is the safe rule. If holes must be closer, they are molded halfway through for precise location, and drilled rest of the way to avoid tear-out. Hole spacing and location can be very precise and, as with phenolics, are limited only by shrinkage during the molding cycle. In present state of the art, hole diameter-to-depth ratio should be kept less than 4:1. Where pins, to form molded holes, must be held at both ends during molding, transfer molding is preferred over compression molding.

Inserts are most commonly used for threaded mounting holes, where the part will be assembled and disassembled frequently. They may be retained by knurling, shoulders, or simple V-grooves. This last method works well because the premix material shrinks slightly on cooling, putting the insert under compression. Shoulders are specified for maximum pull-out resistance. To give enough strength to the molding around the insert, a minimum of ⅛-in. wall is usually specified. Any metal is suitable, since the polyester molding compound does not corrode or leach under any environment where the metal insert will stand up.

Wall thicknesses have varied from a minimum of 0.03 in. (for small coil forms) to 6.00 in. (for gate valve body). Generally 0.060 in. is considered minimum for parts under 100-sq in. surface area. Even very large parts can have wall thicknesses down to 0.090 in. (held in a tub-like part 24 in. x 24 in. x 18 in.). Abrupt changes in thickness constitute a more serious problem than holding these max and min values.

Taper is not necessary where the part has a depth-of-draw from the mold of less than 3 in. and where wall section there is over 0.125 in. Above this depth, 1° taper is usually specified for molder convenience. With tub-shaped parts about 18 in. deep, 2 or 3° taper is desirable.

Shrinkage in the mold varies from about 1 to 6 mils per in. of thickness, with the lower glass content premixes having the higher value. Avoiding shrinkage problems, however, is primarily the molder's responsibility. There are certain tolerances the designer can expect consistently with polyester premixes. For example: a hole of 1 in. dia can be specified to ± 0.001 in. in the high-glass-content compounds, and ± 0.002 in. in the low-glass ones. On length, a tolerance of about 0.001 in./in length is reasonable.

Post-molding shrinkage is much lower than for ureas, melamines and phenolics because the chemical setting reaction is 100% completed in the mold. Thus, where a part heat-ages in service, polyester premixes will retain maximum dimensional stability—provided only that the 300-F continuous-service temperature limit is not exceeded.

Threads can be either molded or tapped, but should be coarser than 8-32. Threads in the higher impact materials give strengths equivalent to brass threads. Tapped, rather than molded threads, are getting widest acceptance because they are found to be about twice as strong. They have better-knit fibers throughout the thread profile; also, exposing the fiber ends by cutting gives better grip on the inserted fastener. The tapped-hole category includes those where a starting hole is molded or drilled, and the thread is cut by self-tapping fastener.

Surface finish of any mold surface can be reproduced precisely, provided serious undercuts on sidewalls are not present. Good surface reproduction is characteristic of polyester resins. With premixes, however, there is a distinct tendency for the as-molded surface to ripple—owing to the different thermal shrinkage rates of glass and resin, and the relatively low pressure of molding. Proper glass distribution is a problem here too. Since the resin contracts on cooling more than the glass, any resin-rich (or glass-poor) areas will be slightly thinner than normal—thus the wavy appearance.

This rippling is more of a problem with the higher-impact premixes, but not necessarily with the higher-glass-content premixes: A 25%-glass-content material can have a perfect surface along with a low impact if mixing is prolonged enough to shred the glass to very short length. Until compounds that give better finish become available, the best design procedure, when finish is critical, is to specify a 1 to 2 ft-lb/in. impact material to get optimum finish—sacrificing slightly on flexure strength and modulus.

Other Design Considerations

Of the two processes used for premix parts, compression molding is selected when maximum mechanical and physical properties are required; transfer molding when the parts are small and delicate, or require delicate inserts. These easily damaged inserts can be clamped at both ends in transfer molding—avoiding a parting line and hence internal flash. Such flash, even though very slight because molding pressures are low and the knitted fibers hold the plastic in place, is troublesome when access for cleanup is limited or impossible. Transfer molding is also desirable for volume production of small parts through multiple cavity molds.

For REPRINT of above article, just check P12 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: Other recent articles on reinforced plastics include:

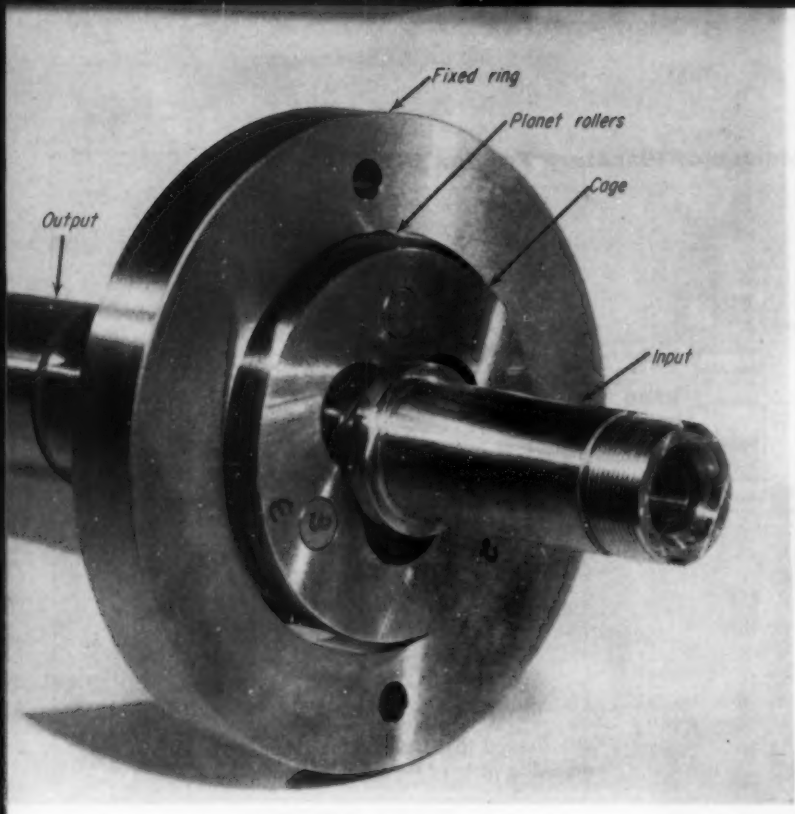
Three New Epoxies Join the Pre-preg Laminates, Aug 31 '59, p 38—presents a resin series combining good high-temp performance with long shelf life.

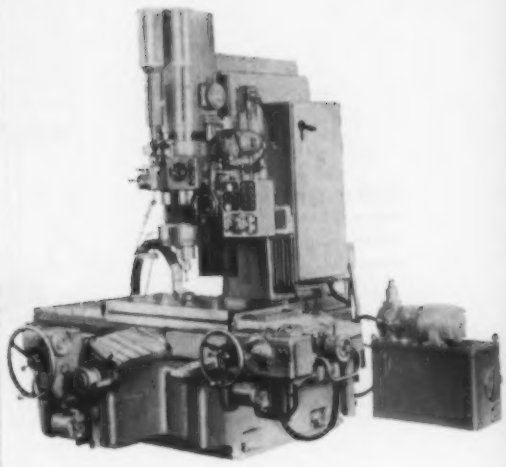
Filament Winding Grows Up, July 20 '59, p 46—after several successful years in the aircraft industry, this high-speed process is ready for more work.

Selecting Plastic Laminates for Punching, Feb 2 '59, p 57—ready-reference chart relates punching ease of various laminates to their electrical and mechanical properties.

Fiber-reinforced Plastics, Feb 3 '58, p 69—how 14 organizations have formed a team to set reliability standards for reinforced plastics. Five experiments cover 6 variables, with Graeco-Latin square analysis to make each test count.

Comparison of Phenolic- and Polyester-Premix Materials, Mid-Sept '58, p C12—three pages of basic property data, showing how the new phenolics compare with typical polyesters.





Friction drive . . . (left) provides smooth speed reduction —50,000 down to 10,000 rpm—in pneumatic grinding head of Pratt & Whitney's vertical grinder (above).

high speeds are smoother, quieter with . . .

THE PLANETARY FRICTION DRIVE

Here's the latest way to cut noise and vibration in a fast-operating planetary system . . . replace the gears with preloaded friction rollers. The necessary calculations are not simple, however, so the author gives his step-by-step procedure.

machine designer
Pratt & Whitney Company Inc, West Hartford, Conn

There is a definite trend nowadays to favor friction drives over gear trains—especially in high-speed devices where the need is for less vibration and noise. All-steel planetary friction drives, however, have seldom been employed because of the difficulty of maintaining tight tolerances between the various components of such drives—outer ring, planet rollers and sun roller.

The design described here overcomes this difficulty by employing interference-fit tolerances to preload the rollers, and an undersize ring which flexes as the planets roll around its inside surface. This type of drive produces almost no vibration while giving a 5:1 speed reduction in the pneumatic grinding head illustrated above. Such drives are expected to find wide use in machine tools. However, they call for a careful step-by-step analysis. The example that follows incorporates actual figures used in the grinding-head application.

EXPLORATORY DESIGNS

Basic requirements here were not unusual:

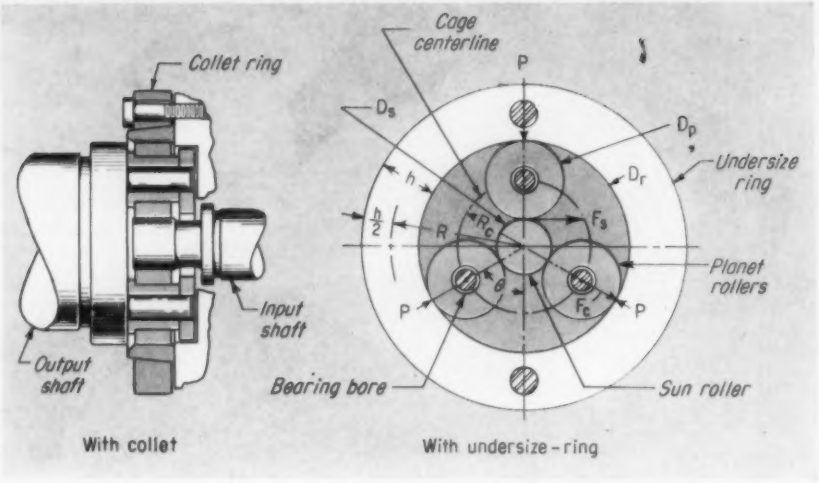
1. Speed to be reduced from 50,000 to 10,000 rpm.
2. Unit to deliver 1 hp at 10,000 rpm.
3. No slippage under starting torque.
4. Minimum vibration.

First attempt was a planetary gear drive, and a set of precision gears was cut. But with pitch-line velocities exceeding 5000 feet per min, the unit turned out to be noisy as well as costly. *(CONTINUED, NEXT PAGE)*

REPRINTED circle P11, inside back cover

Two Versions of Planetary Friction Drive

Collet type . . . was exploratory version. Undersize-ring type proved more successful.



Symbols

D_p = Diameter of planet roller
D_r = Inside dia of fixed ring
D_s = Dia of sun roller
F_c = Centrifugal force of planet
F_s = Driving force at periphery of planets
G = Rolling resistance
P = Force on rollers to transmit driving force (resulting from the interference fit)
P_1 = Max dynamic pressure on ring
P_2 = Max dynamic pressure on sun
r = Speed reduction ratio
R = Mean radius to fixed ring
R_c = Radius at which planet revolves
S = Compressive stress
t = Thickness of planet or sun
T_c = Torque output of cage
T_s = Torque at periphery of sun
γ = Poisson's ratio
δ = Deflection
μ = Coefficient of friction

Second design was a planetary friction drive with a collet-type compression ring on the outside as shown above. As with the gear planetary drive, the input shaft rotated the planet assembly with its three rollers around the inside of the ring, which was fixed to the machine. The planet assembly drove the output shaft. Cost of the unit—three matched planets, sun roller and fixed ring—was less than the equivalent gear drive.

Necessary pressure on the rollers to prevent slippage was obtained by tightening the collet screws. But there was no way of knowing the resulting pressure on the rollers. Also, the unit absorbed too much power—but the power it did deliver gave much less vibration than with gear drives.

Final design replaced the collet-ring assembly with a plain ring properly undersized to produce the required pressure on the rollers. Oversize pin holes permitted aligning the ring and planets. The ring is continuously deformed by the planets as they revolve around the sun. Tests showed that wear of the rollers or oil film on the surface has little effect on operation.

DESIGN PROCEDURE

In designing such a friction drive these factors must be determined:

- General dimensions of rollers and ring.
- Torque and load characteristics—taking into consideration that centrifugal force will increase the pressure between planets and ring—but reduce pressure between sun and planets.
- Deflection of the fixed ring.
- Deformation of contact surfaces under pressure, and resulting stresses.
- Roller width. Permissible contact stresses play an important role here.
- Efficiency of the drive.

General Dimensions

Bore of the planets was arbitrarily selected as 0.250 in. Also chosen was $D_s = 0.500$ in. (see Symbols). Since $r = \frac{1}{3}$, D_r is determined by:

$$r = \frac{D_s}{D_s + D_r} = 1/5 \text{ or } D_r = 5\,(0.5) - 0.5 = 2$$

Therefore, $D_p = \frac{1}{2}\,(D_r - D_s) = 0.750$, and $R_c = 0.625$.

Torque and Load Characteristics

Requirement is to deliver 1 hp at 50,000 rpm, or 1.25 in.-lb of torque. Therefore torque at periphery of planets is equal to:

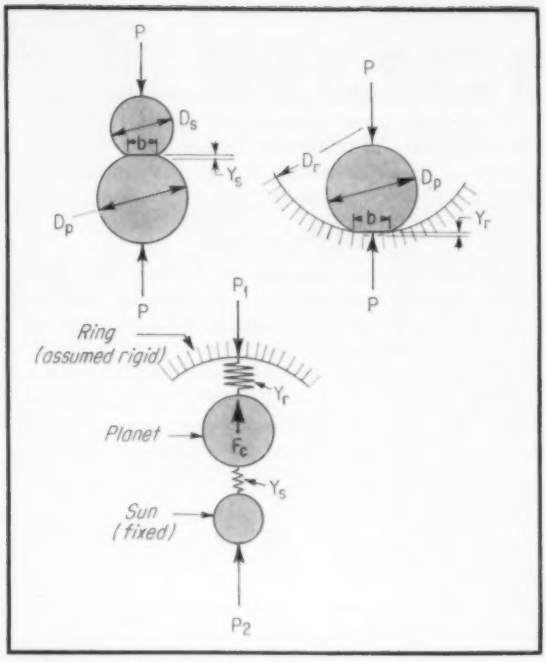
$$T_s = 1.25/0.25 = 5 \text{ in.-lb}$$

and torque output of cage is equal to:

$$T_c = 5\,(1.25) = 6.25 \text{ in.-lb.}$$

Actual driving force on periphery of planets is: $F_s = 5/3$ planets $= 1.67$ lb. Load on each planet pin is $2(1.67) = 3.34$ lb.

Centrifugal weight of a planet ($W = 0.041$ lb) at maximum output ($n = 10{,}000$ rpm) is



Deformed rollers. . . .
show relation between width of deformation, *b*, and height of deformation, Y_s or Y_r.

$$F_c = \frac{0.000{,}341\ WR_c n^2}{12} = \frac{0.00,341(0.041)(0.625)(10{,}000)^2}{12} = 73 \text{ lb}$$

Therefore, required force on rollers to transmit the driving force, with $\mu = 0.128$, is

$$P = F_a/\mu = 1.67/0.128 = 13 \text{ lb}$$

Deflection of Ring

Adding a safety factor of two, max pressure of a planet on the ring is $2(P + F_c) = 2(13 + 73) = 172$ lb. Deflection of the fixed ring was calculated from the following equation given on p 158 in *Formulas for Stresses and Strain*, by Roark:

$$\delta_P = \frac{PR^3}{2EI}\left[\frac{1}{s^2}\left(\frac{1}{2}\theta + \frac{1}{2}sc\right) - \frac{1}{\theta}\right] = \frac{PR^3}{2EI}k$$

where $s = \sin\theta$, $c = \cos\theta$, for a 3-planet system equally spaced; and k equals:

$$k = \frac{1}{s^2}\left(\frac{1}{2}\theta + \frac{1}{2}sc\right) - \frac{1}{\theta} =$$

$$\frac{1}{0.866^2}\left[\left(\frac{1}{2}\right)\left(\frac{\pi}{3}\right) + \left(\frac{1}{2}\right)(0.866)(.500)\right] - \frac{3}{\pi} = 0.035$$

Choosing $t = 0.44$ in., $h = 0.562$ and $E = 30 \times 10^6$, then $R = 1.282$, $I = th^3/12 = 0.006{,}5$ in.^{4} and $EI = 0.195 \times 10^6$.

Thus

$$\delta_P = \frac{(172)(2.1)(0.035)}{(2)(0.195)(10^6)} = 0.000{,}032{,}4 \text{ in.}$$

Deformation of Surfaces

Deformation between sun and planet rollers is then calculated, referring to Roark, p 288, by employing $\gamma = 0.3$ and $t = 0.41$ (see illustration at left for locations of b and Y_a).

$$b = 2.15\sqrt{\frac{P\,D_p\,D_s}{Et\,(D_p + D_s)}}$$

$$= 2.15\sqrt{\frac{(172)(0.75)(0.5)}{(30)(10^6)(0.41)(0.75 + 0.5)}} = 0.004{,}4 \text{ in.}$$

$$Y_a = \frac{2(1-\gamma^2)P}{\pi Et}\left(\frac{2}{3} + \frac{\ln 2D_p}{b} + \frac{\ln 2D_s}{b}\right) = 0.000{,}096 \text{ in.}$$

Also, deformation between planet and ring is

$$b = 2.15\sqrt{\frac{(172)(2)(0.75)}{(30)(10^6)(0.41)(2 - 0.75)}} = 0.008{,}8 \text{ in.}$$

$$Y_r = \frac{2(1-\gamma^2)P}{tE}\left(1 - 2\ln\frac{b}{2}\right) = 0.000{,}31 \text{ in.}$$

Thus, total deformation is

$$Y_a + Y_r + \delta_P = 0.000{,}096 + 0.000{,}31 + 0.000{,}032 = 0.000{,}43 \text{ in.}$$

This total is also the total combined wear permissible in the planetary system. Inner dia of the ring must be $2.000{,}00 - 0.000{,}86 = 1.999{,}14$. Therefore a manufacturing tolerance is chosen of 1.999,2 to 1.999,1, which is obtained by precision lapping.

Contact Stresses

Static contact stresses caused by load P on sun and planets are

$$S_c = 5910\sqrt{\frac{P}{t}} = 5910\sqrt{\frac{172}{0.41}} = 121{,}000 \text{ psi}$$

and on ring and planet:

$$S_c = 2955\sqrt{\frac{P}{t}} = 60{,}500 \text{ psi}$$

Although centrifugal force, F_c, will reduce stresses on the sun roller, it increases stresses on the ring. Thus for static loading:

$$P = P_1 = P_2$$

where P_1 and P_2 are defined in the above illustration. However, for dynamic loading:

$$P_1 = P + F_c\left(\frac{Y_a}{Y_r}\right) = 172 + 73\left(\frac{0.000{,}096}{0.003{,}1}\right) = 195 \text{ lb}$$

$$P_2 = P - F_c = 172 - 73 = 99$$

From the above equations, the stresses on the sun at maximum speed will be:

$$S_{max} = 5910\sqrt{\frac{P_2}{t}} = 92{,}000 \text{ psi}$$

and on ring

$$S_{max} = 2955\sqrt{\frac{P_2}{t}} = 64{,}000 \text{ psi}$$

Because 52100 steel (Rockwell 60-63) is employed, with dynamic stress limit of 100,000 psi, the above values are within limits. Radial force on planets caused by rotation on their own axis is small here and is neglected.

Dynamic Stresses on Ring

Compression stress on inner radius of ring is

$$S = -0.1889(1 + h/2)KP$$

where $K = [(h/2 - e) - e]/Ae$

(CONTINUED, NEXT PAGE)

THE PLANETARY FRICTION DRIVE (CONTINUED)

and

$$e = 1 + \frac{h}{2} - \frac{h}{\ln (1 + h)}$$

Dimensions of the ring are: $h = \frac{9}{16}$, $t = 0.44$; therefore the cross-sectional area $A = \frac{9}{16} \times 0.44 = 0.248$ in.^{2} Load P_1, in this case, is equal to 172 + 23 = 195 lb. Thus

$$e = 1 + \frac{0.562}{2} - \frac{0.562}{\ln (1.562)} = 0.021 \text{ in.}$$

$$K = 46 \text{ in.}; S = 2160 \text{ psi}$$

Bending moment, M, at section under roller is

$$M_{max} = S/K = 2160/46 = 47 \text{ in.-lb}$$

Efficiency of the System

The rolling coefficient of friction for surfaces that are well finished and slightly oiled ranges from 0.000,5 to 0.001. Because the surfaces are well-oiled and superfinished in this example, a value of 0.000,5 is employed. Thus, the sun rolling resistance, G_s, in units of hp is (for a three-planet system):

$$G_s = \frac{3 \mu PV}{33{,}000}$$

where $P = 99$ lb (172 − 73 = 99), and

$$V = \left[\frac{0.5\ (50{,}000)}{12}\right]\left[\frac{D_r}{D_r + D_s}\right] = 5{,}236 \text{ ft/min.}$$

Therefore

$$G_s = \frac{(3)\ (0.000{,}5)\ (99)\ (5{,}236)}{33{,}000} = 0.024 \text{ hp}$$

Planet rolling resistance, G_p, is determined similarly by employing $P_1 = 195$: $G_p = 0.047$ hp.

Sum of all losses is 0.024 + 0.047 = 0.071 hp. Therefore over-all efficiencies of the planetary system is equal to 1 hp − 0.071 hp = 0.929, or approximately 93% efficiency.

Bearing Calculations

Sun rotates at 50,000 (π) (D_s) = 6,535 ft/min. Planet rotates at 10000 $(D_r D_p)$ = 26,667 rpm. Therefore, the planet contacts the ring—or sun—at 26,667 (π) (D_p) = 5,236 ft/min. Bearing load = 3.34 lb, rotating at 26,667 rpm. Bearing dimension = 0.250 I.D. × 0.500 length.

PV factor of the bearing is computed from manufacturer's formula (Oilite bearings were employed):

$$PV = \frac{Wn}{12L} = \frac{(3.34)\ (26{,}667)}{(12)\ (0.500)} = 46{,}636$$

A PV factor under 50,000 is considered satisfactory here—especially since hardened pins are used. Lubrication is by means of an oil-mist system—three drops per min; or six cc per hr, passed through the grinding head at 85-psi air pressure using 10 ft^3/min.

DESIGN DETAILS

Clearance holes are provided for the stop pins which restrain the ring from rotating. This permits the ring to flex freely as the planets rotate by, and the planet system to seek its own center as a unit.

The planet bearing pins also have a built-in clearance of 0.001,5 in. and were set in the carrier 0.000,5 in. below basic position to form an oil wedge in the bearing, compensate for local deformation between sun and planet, and be free of added loading caused by centrifugal force.

To assemble the planets, the ring is heated to 200 F. Basic dia of fixed ring at 70 F is 1.999,14; at 200 F it expands to 1.999,14 + (0.636 × 10^{-5} × 130) = 2.000,7, which is 0.000,7 in. larger than the basic 2.000-in.-dia over planets and sun assembly.

The unit is assembled while the ring is at elevated temperature and allowed to cool at room temperature. When the ring has cooled, the operating temperature will be common to the entire system and relative fits will remain stable. To disassemble, the ring is heated and the sun shaft pulled out. Should the assembly rotate with a slight "bumpy" feeling, disassemble and lap the ring to lay grain in the direction of rotation.

For REPRINT of above article, just check P11 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: For the latest developments in straight-reduction friction drives, see:

"Friction Drive Features Spring-Loaded Idlers," July 6 p 54. Reprints of this article are still available—check E92 on one of the Reader Service cards.

Extremely high speed reductions can be obtained by pairing helical with spur gears in an otherwise standard planetary system. For details, see "Novel Concept Gives Record Gear Ratios," June 22 p 67. For a reprint, check E88.

coming:

THESE TWO FEATURES HIGHLIGHT THE OCT 26 ISSUE

. . . STRUCTURAL MODELS

Properly designed scale representations predict stress and strain, give product planners a preview of how the full-size counterpart will react to load. Three experts from Battelle Memorial Institute tell how it's done—in an 8-page special report that is one of several features in the Oct 26 issue. Each author tackles his own specialty: Dr. Ralph Simon shows how to design the model by applying the theory of similitude; R. G. Carlson takes a look at some model-building materials that have unique properties; C. W. Bert gives suggestions for applying loads and measuring their effect.

. . . 18 WAYS TO CONTROL BACKLASH IN GEARING

Backlash is bound to creep into your gear train—no matter how accurately the gears are made—unless you employ a device that specifically neutralizes this trouble. In this article—another for your file, the author details some of the latest antibacklash methods. He is F. T. Gutmann, development engineer, ITT Labs.

first in silicones

Dow Corning

SILICONE NEWS

for design and development engineers • No. 67

HOW TO STOP TONS

How to bring massive earth-moving machines to quick, positive stops time after time? That was the design problem. Le Tourneau-Westinghouse found the solution in using actuating-pressure brake diaphragms made of Silastic®, the Dow Corning silicone rubber.

Engineers estimate that rubber-tired giants like the 70-ton Tournapull expend five times more mechanical energy in coming to a stop from a speed of 30 mph than an automobile uses in coming to a stop from 80 mph. Brakes installed on all four wheels of these massive vehicles must absorb energy at the rate of 1700 BTU per second when making a quick stop.

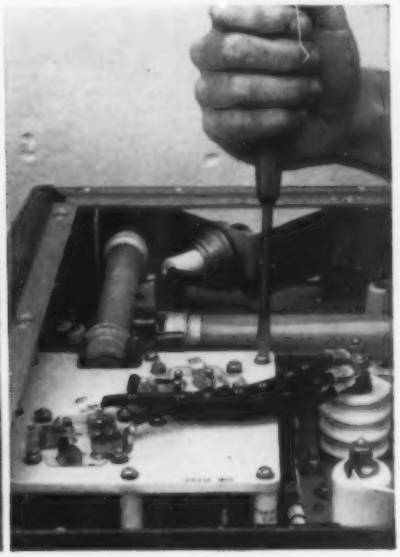
Naturally, when this kind of energy is converted into heat a few successive times, temperatures inside the brake units rapidly rise past the boiling point . . . with intermittent highs in excess of 500 F.

LeTourneau-Westinghouse assures reliable braking by utilizing Silastic coated, glass-cloth actuating pressure diaphragms. Placed in test service in March 1956, these silicone rubber diaphragms proved so successful the company standardized on Silastic for all its 20 to 70 ton machines.

Yale Rubber Company, Sandusky, Mich., engineered the diaphragms which, under

test, have repeatedly withstood 100,000 half-inch flexings while intermittently exposed to temperatures in the range of 500 F, without loss of their original shape, strength or elasticity. Expectations of a 500% increase in the service life of the diaphragms have been fulfilled.

This is another instance where the unusual properties of Silastic have helped designers meet rigid performance requirements and increase service life. **No. 242**



SILICONES AID FLIGHT

Where top reliability is a must, you can depend on silicone-glass laminates. A case in point: the Quadradar navigational aid produced by Gilfillan Brothers, Inc., Los Angeles.

Quadradar provides vital flight information that facilitates ground controlled approach and landing of new, high-speed military and civilian aircraft. Now in world-wide use, this system consists of two units: a receiver-transmitter and an operating console. Its coverage gives altitude, azimuth, and range position on straight-in penetration approaches from 50,000 feet and 40 miles to touchdown. This enables the ground operator to effectively maintain surveillance and to guide jet craft to landing strip in minimum time.

To assure dependable uniform performance, whether operating in the Arctic or the tropics, Gilfillan engineers specified silicone-glass laminates. Safeguarding the system's dependability, silicone-glass laminates prevent recurring arcing under high voltage and high humidity conditions, have low moisture absorption, and provide low loss factor and low attenuation at RF frequencies. Made of glass cloth bonded with a Dow Corning silicone resin, these laminates retain excellent dielectric and mechanical properties even after long term aging at 250 C.

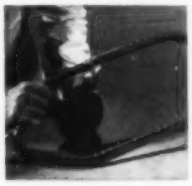
What's more, silicone-glass laminated parts are relatively unaffected by vibration. They are easy to fabricate and light in weight.

These are the reasons why Gilfillan engineers specify silicone-glass laminates with confidence wherever reliability is a major performance requirement. **No. 241**

New Tape Simplifies Processing

New Guideline triangular tape now makes possible silicone rubber electrical insulation systems at costs competitive with other form-wound coil insulation systems. The reason: processing economies resulting from the tape's unique triangular construction and self-adhering properties.

A Dow Corning development, Guideline tape made of Silastic® retains exceptional electrical and physical properties from —90 to 250C, resists arcing, ozone and corona. It produces a homogeneous resilient insulation system resistant to heat, cold, moisture, many chemicals and corrosive atmospheres.



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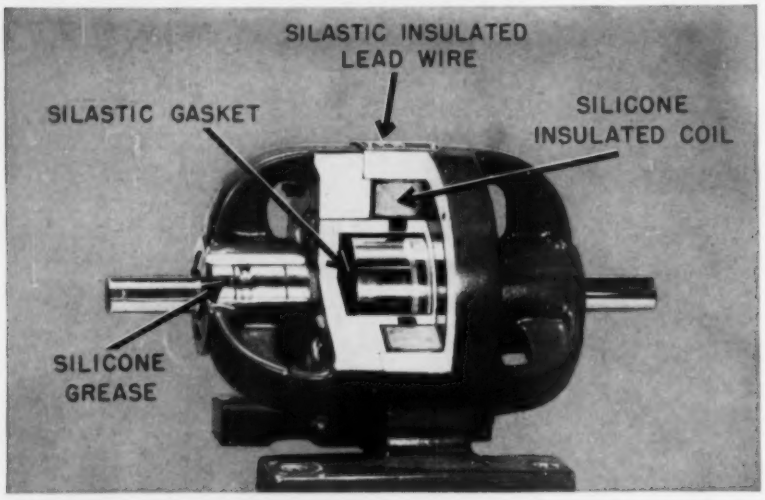

CLUTCH PLAYERS HELP TEAM WIN

Engineers frequently solve tough design problems "in a clutch" with silicones. An excellent demonstration of this is the successful operation of the magnetic clutch produced by Vickers Incorporated, Electric Products Division, Sperry Rand Corp., St. Louis, Mo.

By controlling torque through a magnetic-particle field, Vicker's Magneclutch assures smooth acceleration of rotating equipment without chatter or grab. Since the Magneclutch can slip continuously, the unit must dissipate the heat that is produced. It's not surprising, therefore, to find heat-resistant Dow Corning silicone products including coil insulation, lead wire, lubricants and mechanical gaskets playing an important role in the design.

One critical component requiring silicone protection is the excitation coil which produces the torque-controlling magnetic field. Insulated with silicone components and dipped in Dow Corning 997 Varnish, the coil will readily withstand temperatures far in excess of those permitted by other insulating materials. This silicone insulating system permits operating at temperatures of 180 C or better.

Lead wire to the excitation coil is insulated with Silastic®, the Dow Corning silicone rubber. Gaskets made from Silastic are used as seals between the end shield and outer rotating cylinder. Finally, nonoxidizing, nongumming silicone grease is used to lubricate the ball bearings.

How reliable is the finished unit? Field reports indicate that Magneclutch units require virtually no maintenance and easily last the life of the equipment to which they are applied. *No. 243*

SILASTIC TAPE *(Continued)*

Cost-saving advantages include:

One wrap only. A single wrap of Guideline triangular tape of suitable thickness is all that's needed to produce the entire primary insulation wall thickness.

Self-adhering. The tape bonds to itself . . . requires no pasting. What's more, the tape's beveled edges overlap smoothly . . . produce a void-free insulation structure.

Easy to apply. A conspicuous center line makes it easy to achieve a precise half-lap construction of uniform thickness.

Insulation systems made of Silastic permit use of open motor frames in contaminated areas where totally enclosed motors might otherwise be required. For full information plus a list of companies producing insulating materials made from this silicone rubber, circle . . . . . *No. 244*

new literature and technical data on silicones

Tapes That Stick — Dow Corning silicone pressure sensitive adhesives make tapes stick to anything. They help achieve serviceability over a wide range of temperatures, resistance to oxidation, weathering, corrosive chemicals, and retention of good dielectric properties. For information on the properties of tapes made with Dow Corning silicone adhesives, and their applications, circle . . . . . *No. 245*

What To Expect in the fuel, oil, and solvent resistance of several Silastic® stocks is the subject of a recently published data sheet. This three-page bulletin discusses factors affecting various types of silicone rubber including temperature, duration of exposure, swelling and softening, and contains a comprehensive table of chemical and oil resistance ratings of various types of silicone rubber. *No. 246*

New Dielectric Gel — Now available — a new silicone potting material that permits visual and instrument checking of electronic assemblies and has good thermal stability, low mechanical stress, and physical stability. Convenient to use, it pours like a liquid, then gels into a crystal clear, self healing dielectric that cushions and protects against vibration, shock, moisture, dirt and dust. A new illustrated brochure contains a table of properties and facts you'll want to consider about Dow Corning Dielectric Gel. *No. 247*

Syl-off Sources — A complete listing of approved producers of paper and paper products coated with Syl-off is now available. Listing includes producers of just about every kind of paper that will provide quick, easy and inexpensive release . . . kraft, glassine, parchment, multiwall bags, tissue, asphalt packaging containers and board, food grade coated papers. *No. 248*

You Can Provide up to 100% longer surface protection if you specify silicone-based paints for the domestic appliances and the industrial equipment you design. A unique, full page graph in a 4-page brochure will help you choose the type of paint best suited for every application. A separate listing of producers of silicone paints is included. *No. 249*

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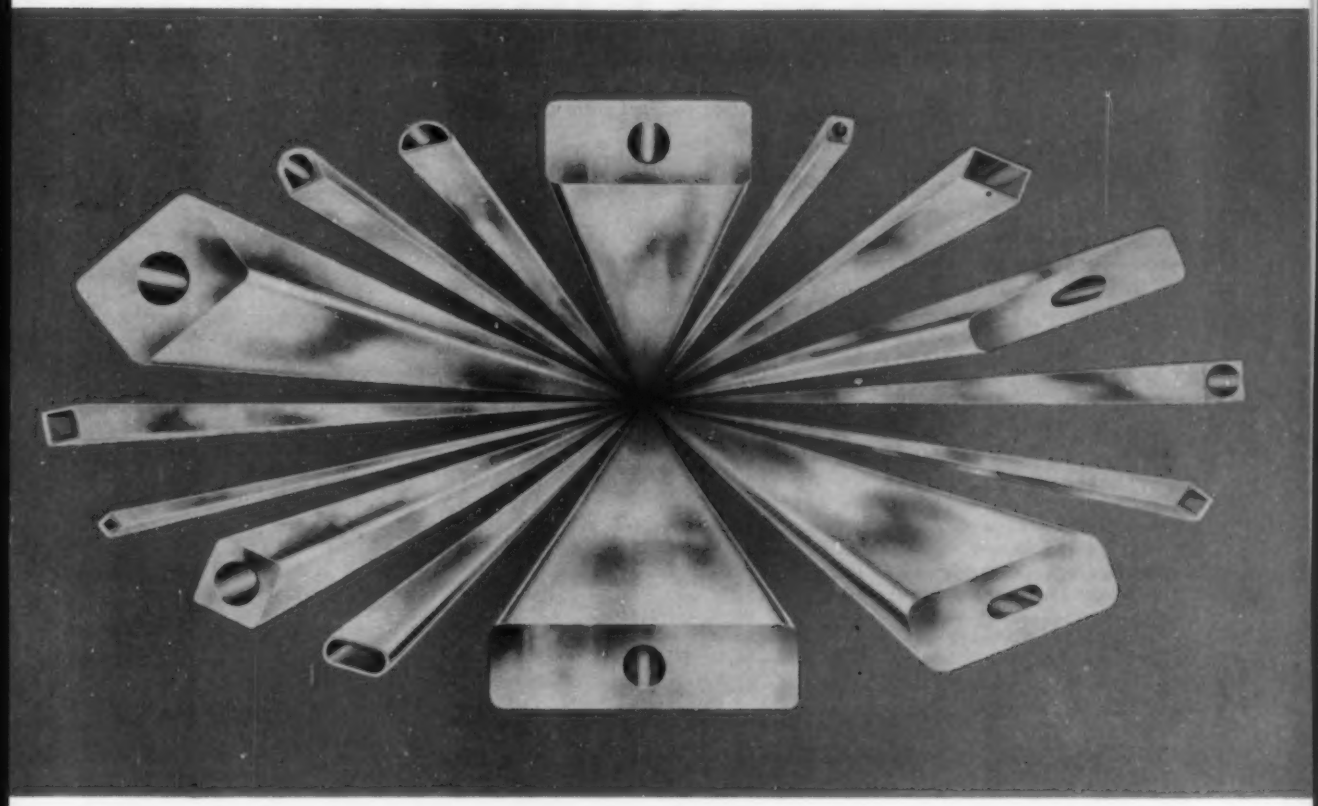

Fluid-cooled copper conductors. The growing need for compact electrical assemblies which can handle high current densities is leading to an ever-increasing variety of hollow, fluid-cooled copper conductors. The samples shown about three-quarters full size above give some idea of the range of sizes and shapes produced by The American Brass Company.

Nuclear physics magnets are, perhaps, the most spectacular applications of fluid-cooled conductors. These hollow conductors range from tube .182" square O.D. x .083" square I.D. to heavy rectangular bars with a round core for water cooling.

Industrial applications. The use of fluid-cooled conductors is growing rapidly in large electrical equipment. Generator output can be greatly increased, without increasing frame size, by cooling stator and rotor bars. Fluid-cooled conductors are being used in heat sinks for rectifiers and induction furnace coils. Another interesting use is in compact water-cooled windings needed to provide very high flux densities in, for example, the ceramic magnet manufacturing process. These "solenoids" are being built for applications in which the current range is from a few hundred to about 2000 amperes.

Technical assistance. Whatever your problem—liquid-cooled field coils, rotor bars or a special-shape tubular conductor—technical specialists at The American Brass Company will gladly help you work out the size and shape best adapted to your needs. See your American Brass representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

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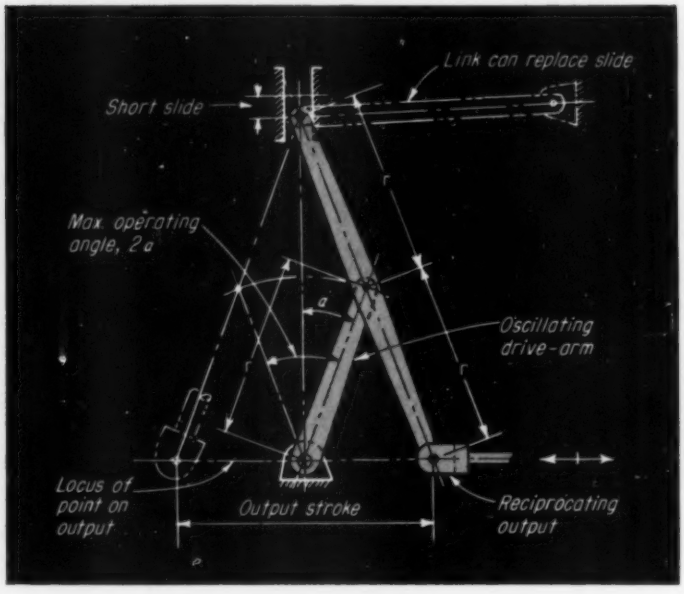
5 LINKAGES for

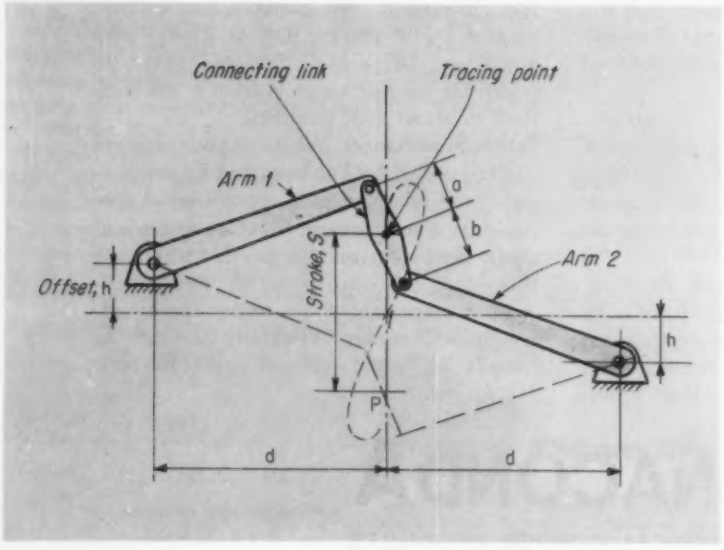
These devices convert rotary to straight-line motion without the need for guides. Five previous examples, based on the Cardan-gear principle, appeared in the Sep 28 issue.

SIGMUND RAPPAPORT, *kinematician*
Ford Instrument Co, Div of Sperry Rand Co



1

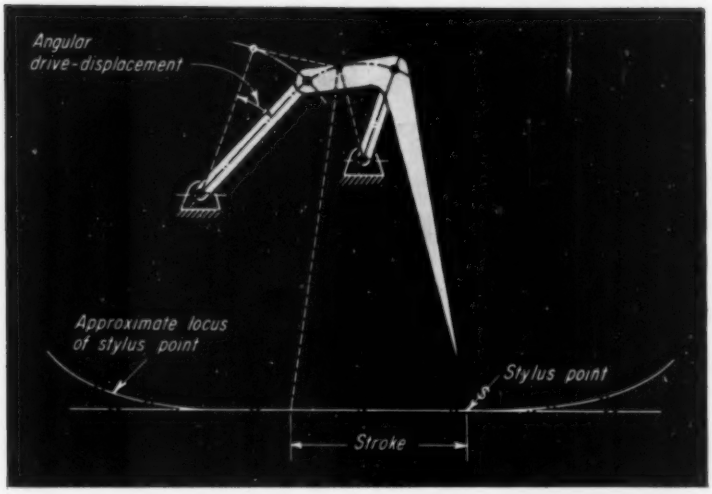
Evans' linkage . . .
has oscillating drive-arm that should have a maximum operating angle of about 40°. For a relatively short guide-way, the reciprocating output stroke is large. Output motion is on a true straight line in true harmonic motion. If an exact straight-line motion is not required, however, a link can replace the slide. The longer this link, the closer does the output motion approach that of a true straight line—if link-length equals output stroke, deviation from straight-line motion is only 0.03% of output stroke.



2

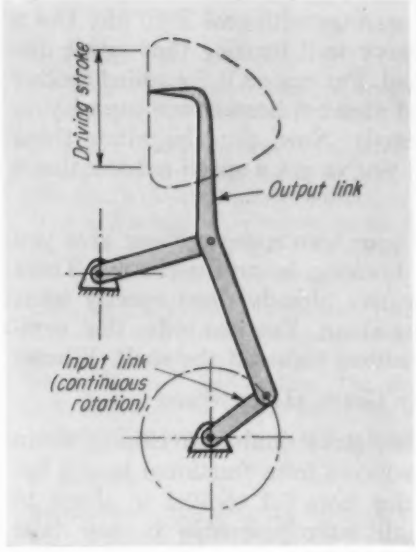
Simplified Watt's linkage . . .
generates an approximate straight-line motion. If the two arms are equally long, the tracing point describes a symmetrical figure 8 with an almost straight line throughout the stroke length. The straightest and longest stroke occurs when the connecting-link length is about ⅔ of the stroke, and arm length is 1.5S. Offset should equal half the connecting-link length. If the arms are unequal, one branch of the figure-8 curve is straighter than the other. It is straightest when a/b equals (arm 2)/(arm 1).

STRAIGHT-LINE MOTION



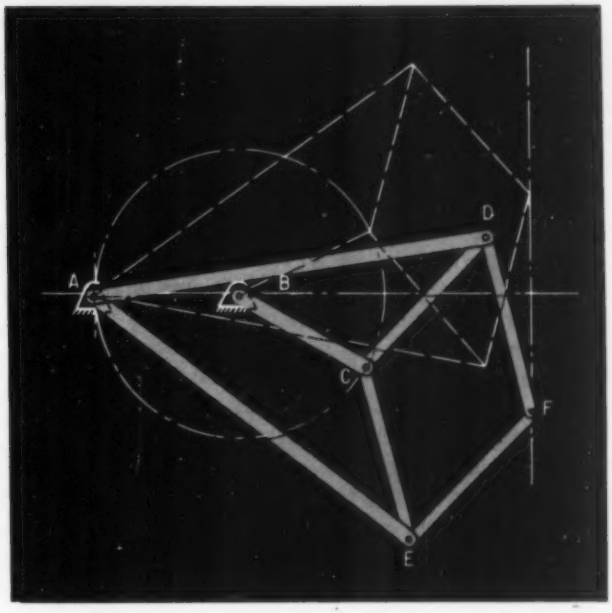
3

Four-bar linkage . . .
produces approximately straight-line motion. This arrangement provides motion for the stylus on self-registering measuring instruments. A comparatively small drive-displacement results in a long, almost-straight line.



4

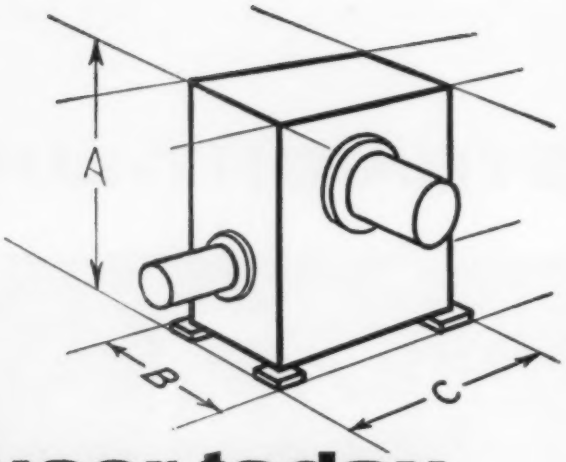
D-drive . . .
results when linkage arms are arranged as shown here. Output-link point describes a path resembling the letter *D*, thus it contains a straight portion as part of its cycle. Motion is ideal for quick engagement and disengagement before and after a straight driving-stroke. Example, the intermittent film-drive in movie-film projectors.



5

The "Peaucellier cell" . . .
was first solution to the classical problem of generating a straight line with a linkage. Its basis: within the physical limits of the motion, *AC* x *AF* remains constant. Curves described by *C* and *F* are, therefore, inverse; if *C* describes a circle that goes through *A*, then *F* will describe a circle of infinite radius—a straight line, perpendicular to *AB*. The only requirements are: $AB = BC$; $AD = AE$; and *CD*, *DF*, *FE*, *EC* are all equal. The linkage can be used to generate circular arcs of large radius by locating *A* outside the circular path of *C*.

Do-It-Yourself...



Let's design a speed reducer today

So you can't find a speed reducer to fit your latest brainchild without ruining the design? Doggone manufacturers all build reducers too big to fit into those few cubic feet you've got left for the reduction unit back behind the double-ended dingbat?

Revolt! Design your own! Show 'em!

By George, design it yourself and it'll fit. How? Well, you know your size limits. Draw the biggest box that'll fit the space and you've got your reducer housing specifications.

Now you need gears that will (1) transmit the needed horsepower under all operating conditions, (2) provide the ratio your machine requires and (3) fit the space that's available. You'll soon discover that there are limits to what gears can do in transmitting horsepower. The cheapest answer is parallel shaft helical gears. If they'll fit you're in clover. But they take the most room, especially when you're out of the fractional hp range. The right angle worm and gear combination is the most compact drive arrangement.

Here again you have a choice. Cylindrical worm gearing is often used, and if it'll do the job, is worth consideration. But it's not the most compact possibility. The best way to shrink gears and still carry the load is the double-enveloping worm gear design. Both worm and gear are throated and the two literally wrap around each other. This brings center distance of the two shafts closer together and you can put them inside smaller housings.

Does this reduce load capacity? No sir! You can carry the same load with center distances up to 33% smaller than those of cylindrical worm gears. Or use the same center distance and carry a greater load. Will these gears hold up in operation? Sure, if you beef up the teeth, the bearings and the housing. Use straight-sided worm and gear teeth and you'll get all the strength there you'll ever need. Use large taper roller bearings with real B-10 life. Use a reinforced, heavy wall housing that won't distort under load. Put fins on it for added cooling and increased thermal horsepower capacity to meet your needs. Now, put the whole thing together and you've got a speed reducer that's a dilly.

Designing your own speed reducer give you a headache? Looking for an easier way? There is one. Someone's already done exactly what you're talking about. You can order that compact speed reducer right off the shelf. Where?

Cone-Drive Gears, that's where!

Yes sir. They stock double-enveloping worm gear speed reducers from fractional to 665 hp. Standard ratios from 5:1 to 70:1 in about 15 increments, all interchangeable in any type housing of a given center distance. Worms over and worms under. Gear shafts vertical, too. Single- or double-extended output shafts, or shaft mounted. Over 200,000 combinations possible. Wow! Just about anything you want.

Better get Cone-Drive's new speed reducer catalog that details everything. Ask for Bulletin CD-218. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

12 SPECIAL ELECTROPLATES —their uses, properties and costs

PETER C NOY, *manufacturing engineer*
Canadian General Electric Co, Barrie, Ont

Virtually all metals have been plated from baths of their fused salts, but only about 30 can be plated from their water solutions. In recent years the need to produce specialized combinations of metals has pulled the lesser-known electroplates out of the laboratory into common commercial use.

Although some of the commercial processes described here are very old, quite often their past use has been less science than "art." Gold, for instance, has been plated for decorative purposes for many years in every color from white to green. The "colorer" who was in charge of bath formulations had secrets which he guarded closely. But the need for plating to close and predictable tolerances has produced the 12 commercial processes described below.

Cost figures are based on cost of the actual metal and only intended to be an approximate guide. Thickness, electrical characteristics of the solution, quality of the plate, and many other factors will affect actual cost of the coating, but generally the base cost of the metal is the big factor.

1. GOLD

Applications: Extensively on jewelry; printed circuits; electrical contacts; houseware; infrared reflectors.

Properties: Excellent corrosion resistance; rich and wide variety of color when plated as an alloy; remains solderable for 12-18 months; low contact-resistance; high reflection of infrared wavelengths; ductile and bright; low electrical resistance; reduces "secondary emission" in TV tubes; too soft for severe mechanical uses.

Cost: High at $560 per lb, but thin coats are practical. Expensive solution means pockets in work, which could drag out solution, must be avoided. Usual size of a gold-plating tank is 20 to 50 gallons. The solution (cyanide) is bought from the supply house, already formulated, and added as needed, so control is largely empirical.

2. INDIUM

Applications: Used generally with other plated metals, since it diffuses into them at low temperatures to form alloy layers. Diffused into copper to produce tarnish resistance, into zinc for increased corrosion resistance on steel, into silver-plated bearings to prevent seizing. Large electronic tubes are sealed by diffusing indium-plated part into gold-plated part.

Properties: Soft white metal—looks like tin. Low melting point.

Cost: Near silver at $40 per lb. Relatively little known but its interesting alloying properties will result in increased use. Some tendency of cyanide bath to be unstable, but freshly prepared solutions are good. No great operational problems.

3. IRON

Applications: Electroforming complex shapes such as wave guides, printing plates, paint masks, slush molds; to assist welding in the production of stainless-clad sheet-metal, embossing and phonograph-record dies.

Properties: Malleable as plated; can be heat treated, machined, ground, etc; poor appearance and corrosion resistance.

Cost: Low—10¢ per lb, an advantage in electroforming, where costs are high. Low-cost chloride, sulphate, or fluoborate solutions contribute to economy.

4. LEAD

Applications: Protects steel against fumes of sulphuric and hydrofluoric acids, where solderability is needed; as a diffused coating with indium in bearings.

Properties: Tends to be porous as plated, but buffing covers the pinholes; quite pure as deposited, thus used for purification of lead; malleable and ductile; inert to most atmospheres.

Cost: 13¢ per lb, but insolubility of most lead salts necessitates plating from solutions of uncommon (and moderately expensive) acids. Fluoborate bath is generally used. Not a difficult process, but more expensive than the low cost of this metal would indicate.

5. PALLADIUM

Applications: In the jewelry field, but is finding increasing use as an undercoat for rhodium since their properties are somewhat the same (palladium cost is lower). It tarnish-proofs silver on contacts and wave guides.

Properties: In the platinum group with rhodium, but not so hard or chemically resistant; not so white as rhodium, but generally has the excellent characteristics of the platinum group of metals.

Cost: High, at $370 per lb, but compared with rhodium and platinum is lowest of the three. (Until recently platinum was falling out of favor as a plating metal because of high costs—$1320 per lb—and brittleness. Now, however, improved techniques give ductile plating with low internal stresses.) Palladium baths have high drag-out cost, but baths (usually chloride) are simple, 100% anode efficiency being obtainable.

6. RHODIUM

Applications: Protects silver and gold in communications

(CONTINUED ON PAGE 91)

AUTO AIRCON STEEL CABLE V-BELTS

Forget your experiences with V-Belts on air-conditioning units

The U.S. Auto AirCon Steel Cable V-Belt has everything required in a belt for air-conditioning use. Here is a V-Belt that's in a class by itself. It is equipped with pulling members of steel. A new patented curing method and electronic tensioning of the steel cords free this belt from vibration. It transmits power smoothly, quietly and efficiently—and in present automotive air-conditioning service lasts 1½ to 2½ times longer than any other V-Belt. Here are the unequalled advantages the engineers point out:

- All-steel cable members lie in the same plane.
- Wire cable members are straight, never wavy.
- Absolute uniform top width and belt thickness for better seating in pulley.
- Perfect dynamic balance.
- Use of knurled mold insert provides maximum traction and alignment of outside idler.

Our transmission belt field engineers stand ready to consult with you on any or all V-Belt problems. Drop us a line at address below. . . .

When you think of rubber, think of your "U.S." Distributor. He is your best on-the-spot source of technical aid, quick delivery and quality industrial rubber products.

Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

circuits; over nickel for tarnish resistance; instrument mirrors; spotlight and infrared reflectors; printed circuits; relays; magnetic, computer, and vibrating contacts.

Properties: In the platinum group of metals; hard, abrasion resistant; white color; inert at ordinary temperatures and outstanding high-temperature stability; good infrared reflectivity, though inferior to gold and silver; outstanding corrosion resistance; good electrical conductivity and contact resistance low. Altogether an outstanding metal.

Cost: Highest at $2220 per lb, but thicknesses of 0.000001 in. to 0.000005 in. normally adequate. About $760,000 worth used per year for plating, so its special properties overcome price drawbacks. Fantastic cost of the solution, however, makes dragout losses of top importance. The highly acid solution requires equipment of top quality. Most baths are as small as possible. Solutions are prepared by supply house, either concentrated or in ready-to-plate lower strengths.

7. SILVER

Applications: Aircraft bearings; piston rings; electrical contacts; printed circuits; jewelry, flatware and hollowware.

Properties: Good corrosion resistance; tarnishes in air, but organic coatings help; good electrical conductivity; low contact resistance; helps bearings "wear in"; can be plated full bright.

Cost: $33 per lb—low enough for wide industrial and decorative use. Dragout must be watched, because silver solutions are expensive, and this could become the highest cost. To prevent initial deposit by immersion, and poor adhesion, a "strike" bath, with low content of silver is used first, followed by plating in regular solution. Chemical control should be precise, because anode current density must be kept within certain limits to prevent "black anodes". Steel tanks may be used.

8. TIN-COPPER ALLOY

Applications: The white speculum alloy (40% to 45% tin) is used for hardware, inexpensive tableware and household fixtures. The low-tin alloy bronze (10% to 20% tin), is used for metal furniture, hardware, rotogravure cylinders and decorative consumer housewares. An industrial use is as a stop-off in the nitriding of steel dies.

Properties: Speculum resembles silver in appearance and can be plated bright, but tarnishes rapidly in industrial atmospheres. Bronze is by far the most important because it offers better corrosion resistance than copper under nickel and chrome. It plates rapidly either bright or dull, and is easily buffed.

Cost: About 80¢ per lb. Because of its high-speed plating, it has replaced copper plating in many applications.

9. TIN-LEAD ALLOY

Applications: Wherever retention of solderability is needed—wire for electronic circuitry, lugs, terminals, printed circuits where eyelets and lugs are fused; as an overlay on bearing surfaces of aircraft bearings; for mass production dip soldering.

Properties: Retention of solderability with good corrosion resistance; soft; ductile; after plating may be reflowed by heating into a nonporous state; may be plated at up to 70% tin, but 30%-50% is more usual.

Cost: Reasonable at 75¢ per lb; a simple process growing in industrial importance.

10. TIN-NICKEL ALLOY

Applications: Kitchen utensils, watch parts, musical instruments, hardware, flatware, valves, pumps, tools.

Properties: A true intermetallic compound of tin and nickel; excellent corrosion resistance; pleasing color and brightness similar to stainless; low coefficient of friction; holds oil by polar attraction; can be plated into deep recesses and thus is used to plate assemblies; plates dense with little local buildup; hardness close to chromium; excellent retention of solderability; decomposes at temperatures above 650 F; not good for corrosion resistance directly on steel, but good with copper or nickel undercoat.

Cost: $1.10 per lb—low enough for wide commercial use. This plate has received wide recognition in the past five years.

11. TIN-ZINC ALLOY

Applications: Lugs, grommets and sockets requiring top solderability retention; hardware; components for low-temperature service formerly tin plated.

Properties: Best solderability—stifles copper-aluminum galvanic couple; composition 78% tin 22% zinc; has excellent corrosion resistance on copper, but is inferior to zinc and cadmium; resists "tin pest"—low temperature decomposition of tin.

Cost: 70¢ per lb. Replacing tin in rapidly growing field of low-temp engineering, where solderability is needed.

12. ZINC-COPPER ALLOY (brass)

Applications: Widely used for door hardware, inexpensive decorative housewares, wire work, lipstick cases, radio and TV dials and decoration, escutcheons. Used industrially to bond rubber to steel and as an undercoat for nickel to bond nickel to aluminum.

Properties: Wide color range, 90% copper is bronze color, 80% copper is brass color; little corrosion resistance so is usually lacquered; engineering-wise, an inferior plate, but widely used because of its transformation of the appearance of steel.

Cost: 30¢ per lb. It plates relatively slowly and is apt to go off-color unless closely controlled.

IN GENERAL, all alloy plating-baths must be kept in close analytical control because, with exception of tin-nickel, the electrodeposited alloys change composition with change in bath composition. Tin-nickel plates from a salt solution, and differs in that it is a true compound (SnNi) and does not tend to wander in composition.

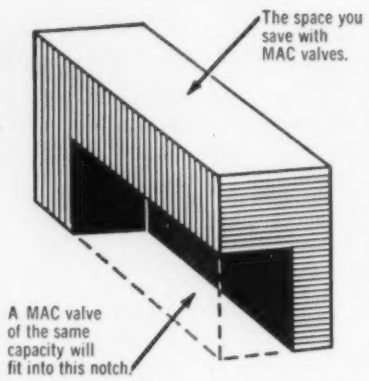
Cuts Air-Valve Size 67% with New Design

Also Boosts Performance, Life, and Ease of Service

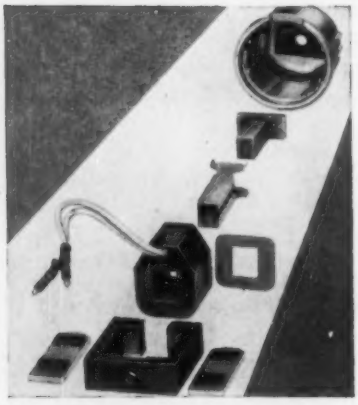
A remarkable new line of pilot-operated air-valves—the MAC series 300—cuts space requirements to ⅓ of that normally required for valves of equal capacity rating.

Not only is the valve extremely simple in operation, reducing cost, but the three moving parts can be replaced in a matter of 1 to 2 minutes without special tools. Life of moving parts is rated at 30,000,000 cycles, minimum.

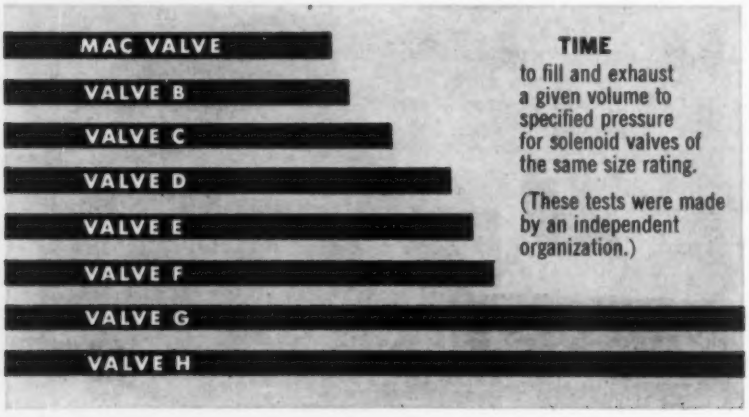
The story of how this was accomplished, together with valve sizes and specifications, is contained in Bulletin #300A available from Mechanical Air Controls on request.



New Solenoid Boosts Valve Life —Virtually Foolproof, it also has Lighter Draw



A virtually failure proof solenoid which can be completely assembled or taken apart without any tools—but which can't be assembled wrong has been developed by Mechanical Air Controls. It has no welds to break or crack. It has no screws, nuts, bolts or other fasteners to work loose. It has a fully encapsulated water and oil resistant coil. There is no wiring through air valve body. The connections just plug in. The entire assembly floats on rubber mounts, the rubber being in shear. The solenoid has a lower draw because of the lighter push required. The design provides for both locking and manual jogging. It is standard on every MAC series 300 air valve.



advances in
PNEUMATICS

MAC

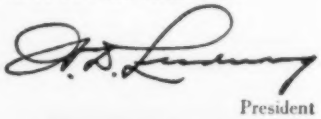
designing an air valve . . .

There are two ways to design air-valves. One is for a specific job, and no more. For example, a valve in a missile usually has to function only once. Wear life is no problem. The other way is to design a valve for the *toughest* job it might face and then use it on easier jobs, too.

Any engineer would prefer the second way, but he wonders "Won't it cost too much?"; or "Won't I be criticized for providing more performance or life than needed?"

His worries are pointless. The second way doesn't have to cost more. Extra performance and quality can be a free "plus." If you design air-valves for the TOUGHEST jobs they can encounter (as we did at MAC) you can naturally get a simpler, more compact, easier-to-service valve; plus extra performance reserve—all AT LOWER COST.

Why? Once the valve licked the toughest application—where speed, reliability, serviceability and life were MOST vital—we simply standardized for mass production. That's how we wound up with a better and lower cost valve . . . the series 300.

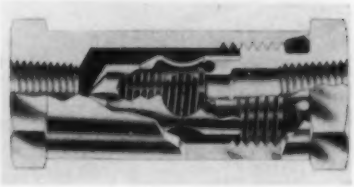


President

MAC

MECHANICAL AIR CONTROLS, INC.
10830 Capital, Oak Park • Detroit 37, Michigan

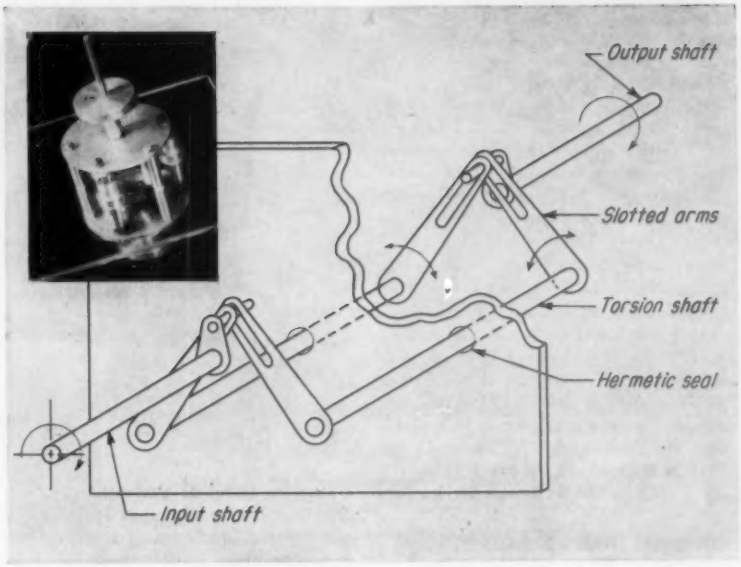
SIGNIFICANT COMPONENTS & MATERIALS



Disk-type check valves . . .

are for 3,000 psi service in air, oil and water. Standard cracking pressure is 0.5 psi. Higher cracking pressures are available on order; lower opening pressures, down to ¼ psi, are from stock. Valves are reported to be leakproof at all pressures. Presently available in ⅛ pipe size in all standard fittings; other sizes and materials are expected to be in production shortly. Prices start at $3.75 each. **Bodnar & McDermott Mfg Co, 19 Beechwood Ave, Mount Vernon, NY.**

Circle 300 on Reader Service Card



Hermetic rotary shaft seal . . .

for vacuum or high-pressure service, operates at cryogenic temperatures or up to hundreds of degrees F. Rotary motion of input shaft moves slotted arms of torsional shafts back and forth, causing torsion shafts to oscillate. Oscillating motion can be hermetically sealed by torsionally flexible tube, such as rubber sleeve, which is bonded to shaft at one end and to bulkhead or wall of enclosure at other end. For most applications, bonded flexible material, such as neoprene or other synthetic, nonporous material, can be used, but an all-metal torsional seal is used for extreme temperatures or pressures. On other side of sealed partition, oscillating motion of two or more torsion shafts are recombined by crank integral with output shaft into usable rotary motion. Torsional resistance of sealing element is said to be balanced in most designs. Motion or power can be introduced at either input or output shaft and in either direction and the other corresponding shaft will follow exactly. Hermetically sealed rotary shaft feedthroughs can be built in small sizes suitable for instrument and electronic applications and as large as necessary to transmit any required horsepower. Pilot production cost of the ½-in. size, illustrated, is $100 each in lots of 10; $30 each in lots of 100; $15 each in lots of 1,000 or more. **Co-Engineering Co, 12 Vale Dr, Mt Lakes, NJ.**

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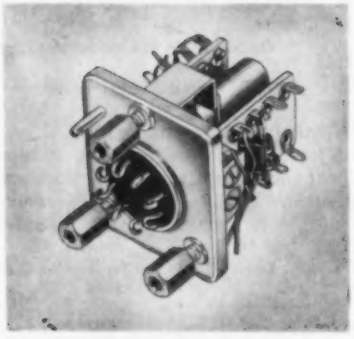

Close differential relay . . .

uses no mechanical devices. Network utilizes static devices in conjunction with microminiature relay. DPDT contact combination is rated 3 amp. Operating voltage is 24±2 v; release voltage is 22±2 v. Max differential between attract and release is 2 v. Foregoing values are applicable over temperature range of −85 to 257 F. Relay is hermetically sealed in housing similar to AN-3304-1 and is available with four-stud mounting and solder hook type header. **Guardian Electric Mfg Co, 1621 W Walnut St, Chicago 12.**

Circle 301 on Reader Service Card

Heavy-duty static seals . . .

withstand pressures up to 20,000 psi and temperatures above 1,000 F. Made of mild steel, stainless steel, cupro-nickel, monel or copper alloy, seals are tubular metal rings containing inert gas under pressure, about 600 psi for average metal-to-metal joint. Single reusable ring retains all normal pressures, but where extremely high pressures are involved, two or more rings can be used. Distortion from undue compression of ring is avoided by housing it in recess of joint. Resulting hermetic seal is reported to expand and contract without damage. Available in sizes from ½ to 96 in. OD, to fit any joint. Can be fabricated in any shape. 3 to 4-wk delivery. **General Hermetic Sealing Corp, 99 E Hawthorne Ave, Valley Stream, NY.**

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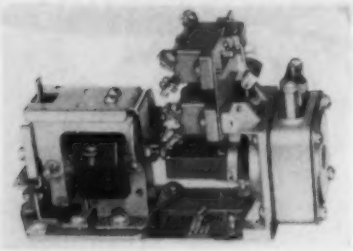


Pneumatic timing relay . . .

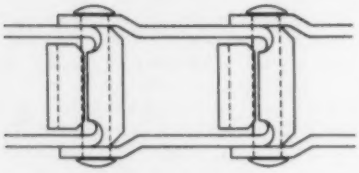
has two normally open and two normally closed timing contacts, each of which can be separately adjusted to provide a definite timing sequence. Therefore, one of the two SPDT snap switches (used for timing contacts) can be set to operate before the other. Up to two instantaneous SPDT interlocks can be furnished. Timing range is adjustable from 0.2 sec to 3 min., with repeat accuracy of 10%. Price, depending upon features and enclosure, ranges from $65 list, for open unit without dials or interlocks, to $90 list, for enclosed relay with dial and two interlocks. Standard dc voltages from stock; ac units to be available from stock within 3 wk. **Square D Co, 4041 N Richards St, Milwaukee 12.**

Circle 304 on Reader Service Card

Enclosed interval timer . . .

is manually set to selected interval, at completion of which, switch opens and de-energizes motor. Rated at 28 amp or 1 hp at 250 v ac. For 120 or 240 v, 50 or 60 cps, with intervals of 1, 5, 15, 30, 60, 120 and 180 min. UL-approved. **General Time Corp, 245 E Elm St, Torrington, Conn.**

Circle 305 on Reader Service Card



Steel pintle chain

adaptable to applications requiring capacities exceeding those of steel detachable chain. Produced in four sizes, 662, 667, 667-H and 672, to standard steel detachable chain pitches. **Locke Steel Chain Co, 1230 Sabine St, Huntington, Ind.**

Circle 306 on Reader Service Card

Electronic millivoltmeter . . .

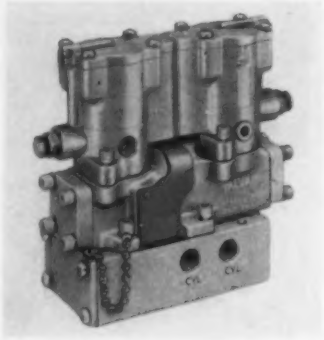
is chopper-stabilized, measures dc voltages from 0.000,5 to 300 v. Operates on 60 or 400 cps. Offers 10 standard ranges, from 0.01 to 300 v, fsd. For panel mounting or portable applications. **Metronix Inc, Chesterland, Ohio.**

Circle 307 on Reader Service Card

Photoconductive cell . . .

is cylindrical, side-on type of cadmium-sulfide cell for use in industrial light-operated-relay applications. Has illumination sensitivity of 300 microamp per ft-c at 77 F; max current capability of 1000 microamp and max power dissipation ratings of 50 milliw. Photosensitive area 0.2 x 0.02 in. **Electron Tube Div, Radio Corp of America, Harrison, NJ.**

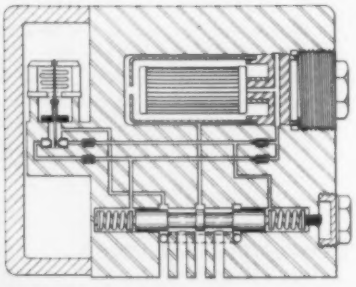
Circle 308 on Reader Service Card



Plug-in control valves . . .

for control of smaller units are offered in single and double solenoid types, for sub-base or multiple manifold mounting. Built-in plugs and connection in pilot, valve body and sub-base complete electrical connections as body and pilot are bolted into place. All pneumatic or fluid connections also are made automatically as components are joined together. For 30 to 200 psi service, available with solenoid coils for ac or dc, any voltage. Exhaust is tapped $\frac{3}{8}$ in. NPT. **Valvair Corp, 454 Morgan Ave, Akron 11.**

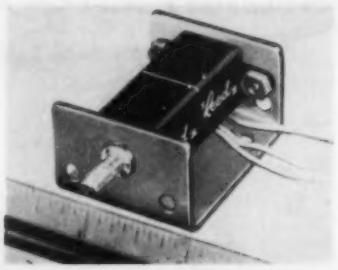
Circle 309 on Reader Service Card



Hydraulic servo valve . . .

with integral field replaceable filter is available from stock in 1, 2.5 and 10 gpm rated flow capacities at 1,000 psi valve drop and 15 milliamp input current. Operates at system pressures from 500 to 4,500 psi. **Industrial Div, Moog Servocontrols Inc, East Aurora, NY.**

Circle 310 on Reader Service Card



Environmental switch . . .

actuated by magnetic circuit, requires no external openings or physical contact to operate. Basic 5-amp unit measures $\frac{3}{4}$ x $\frac{3}{8}$ x 2 in. Offered in 5, 10 and 15-amp sizes. **Space Components Inc, 1048 Potomac St NW, Washington 7, DC.**

Circle 311 on Reader Service Card

Miniature 1-½ hp motor . . .

is said to have output shaft speed of 4,600 rpm. 10-pole, 200 v, 400 cps motor is for continuous duty. Measures 3 in. dia. **Electro Products Div, Western Gear Corp, 132 W Colorado Blvd, Pasadena, Calif.**

Circle 312 on Reader Service Card

Low carbon flat stock . . .

is said to have high machinability (rating 91% against 72% for most low carbon steels). Available in 24-in. lengths in widths from $\frac{3}{8}$ to 16 in. and in thicknesses from $\frac{1}{16}$ to $2\frac{1}{8}$ in. **L S Starrett Co, Athol, Mass.**

Circle 313 on Reader Service Card

Miniature control valve . . .

is for air service utilizing one operator. Body pressure rating for $\frac{1}{4}$-in. block and vent valve is 30 psi; body temperature rating is for ambient air only. **Geo W Dahl Inc, 86 Tupelo St, Bristol, RI.**

Circle 314 on Reader Service Card

Solenoid selector valve . . .

is four-way, three-position unit for 3000 psi, 275 F, service. Uses forged stainless steel body with integral sleeve. Positions are pressure-actuated. **Hydra-Power Corp, Pine Ct, New Rochelle, NY.**

Circle 315 on Reader Service Card

7,000 psi gas relief valve . . .

provides tight seal because seating force of soft metal seat increases as pressure rises. Cracking pressure, reseat pressure and full-flow pressure are close. Pilot controls

. . . CONTINUED ON PAGE 96

PREVIEW OF PROGRESS

NICE BALL BEARING COMPANY
Division of Channing Corporation
Towamencin Township, Montgomery County, Pa.

NICE PLANS LONG RANGE PLANT EXPANSION

First Unit to be Completed in 1959

Nice Ball Bearing Company, Philadelphia, Pennsylvania, a Division of Channing Corporation, has started construction of a new plant addition to be located in Montgomery County, Pennsylvania, approximately 30 miles north of the present Philadelphia plant. The first unit, scheduled for completion in 1959, represents Nice's fourth major expansion since the end of World War II and will provide approximately 40,000 square feet of additional manufacturing area. Future plans for the new location call for an ultimate completely integrated plant of approximately 340,000 square feet.

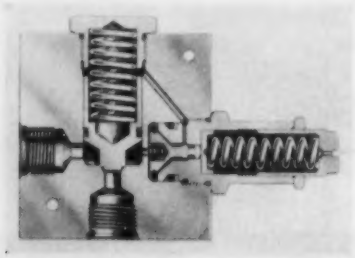
An unprecedented demand for Nice products has created a critical need for additional facilities. Completion of the new facilities now under way will add substantially to manufacturing capacity and will enable Nice to improve deliveries and provide better service to customers during the fourth quarter of this year.

One of the pioneers in the bearing industry, Nice Ball Bearing Company has been a nationally known manufacturer of ball bearings since 1902, producing bearings that are used in products throughout the world.

NICE

NICE BALL BEARING COMPANY
NICETOWN · PHILADELPHIA · PENNSYLVANIA
DIVISION OF CHANNING CORPORATION

CIRCLE 95 ON READER SERVICE CARD 95



opening. Standard connections are internal straight thread, ¼ to ⅜ in.; internal pipe threads, ⅛ to ½ in.; and US Bureau of Standards high-pressure tube, ⅜ and ⅞ in. Body, internal parts are stainless steel. Accommodates 1,000 to 7,000 psi; standand te.nperatures from −65 to 160 F. Delivery, 2 to 4 wk. **Republic Mfg Co, 15655 Brookpark Rd, Cleveland 35.**

Circle 316 on Reader Service Card

Pull-push switches . . .

in 2⅛-in. dia styles. One model has 8-17 oz actuating force with 3-amp, 125 v ac UL rating; other has under 6 oz actuating force and UL rating of 1 amp, 125 v ac. **Chicago Telephone Supply Corp, Elkhart, Ind.**

Circle 317 on Reader Service Card

Direct overtemperature relay...

device for ac applications consists of a magnetic relay, two transistor amplifiers, a diode network for signal separation and a voltage regulated power supply. Power supply ratings are 110, 208 to 220, 440 or 550 v, 60 cps. **Cutler-Hammer Inc, 296 N 12th St, Milwaukee 1.**

Circle 318 on Reader Service Card

Miniature gear motor . . .

requires input of 28 v dc at 65 amp. Output speed can be varied. 1 hp gear motor is less than 2½ in. dia. **Electro Products Div, Western Gear Corp, 132 W. Colorado Blvd, Pasadena, Calif.**

Circle 319 on Reader Service Card

Temperature probes . . .

with integral pipe threads are offered in three types. Two types have min protection for temperature-sensitive winding to provide time constant of about 100 millisec in liquids. Another probe with stainless steel sheath, operates at pressures up to 150 psi. Time constant is 2 sec. **Ruge Associates Inc, Hudson, NH.**

Circle 320 on Reader Service Card

Control valves . . .

in regulating needle and fingertip control types are furnished in stainless steel, Monel and Hastelloy in sizes from ⅛ to ½ in. **Whitey Research Tool Co, 1150 55th St, Oakland, Calif.**

Circle 321 on Reader Service Card

Stronger-than-metal bond . . .

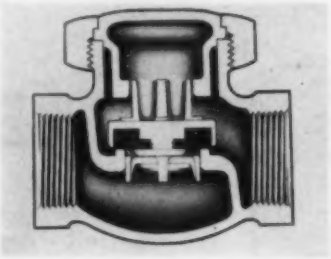
is said to be possible with new adhesive compound. Suitable for bonding aluminum, iron, stainless steel, rigid plastics and many other materials. **Lawrence Adhesive & Chemical Co, 19 S Canal St, Lawrence, Mass.**

Circle 322 on Reader Service Card

Min current sealed relay . . .

meets overload rupture, vibration and min current requirements of MIL-R-6106-C. Operates with 4PDT contact switch combinations at 10 amp. For −85 to 248 F. Standard coil voltage is 24 to 28 v dc. **Guardian Electric Mfg Co, 1621 W Walnut St, Chicago 12.**

Circle 323 on Reader Service Card



Bronze valves . . .

a 200-lb globe valve and a lift check valve, have integral body seals with semi-crown face instead of screwed-in seats. Available in sizes from ¼ through 2 in. Regularly furnished with No. 4 disk, for high pressure steam up to 450 F. No. 6 disk is used for cold water, air, gas, oil or gasoline. **Crane Co, 836 S Michigan Ave, Chicago 5.**

Circle 324 on Reader Service Card

Solid-state time delay . . .

relay in six models, provides three ranges and tolerances. Weighs 4 oz. 1½ x 1⅞ x 1⅜ in. Standard operating voltages, 24 to 31 v dc. **George Harmon Co Inc, 18232 Parthenia St, Northridge, Calif.**

Circle 325 on Reader Service Card

Large induction motors . . .

in open drip-proof enclosures in ratings from 150 to 2,000 hp at 1,800 and 3,600 rpm are for use as drives for pumps, fans, blowers, compressors, machine tools, conveyor. **Louis Allis Co, 427 E Stewart St, Milwaukee 1.**

Circle 326 on Reader Service Card

Module building blocks . . .

are transistor-equipped plug-in units. Blocks include NOR circuits, flip-flops, one-shot multivibrators, blocking oscillators, coupling circuits, drivers for indicators or electromechanical devices. Input and output characteristics of most units almost identical. Operate at 200 kc/s though some may operate at 400 kc/s or higher. **Wang Laboratories Inc, 12 Huron Dr, Natick, Mass.**

Circle 327 on Reader Service Card

Hinged clamp fastener . . .

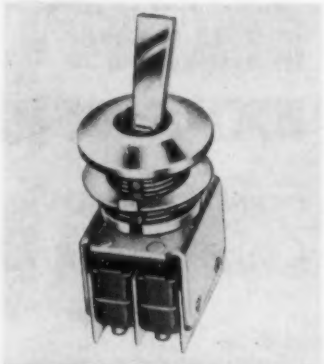
is self-contained. Quick-disconnect nut can be disengaged with 1¼ turn of screwdriver on integrated bolthead. Fastener can be opened and closed without removing from fixed mount. Available in sizes from ¼ to 6 in. dia. All are stainless steel. Asbestos-Teflon, neoprene rubber, AW aromatic fuel and weather-resistant cushion and corrugated stainless are offered as cushioning materials. Delivery, from stock to 3 wk, depending on specifications. **TA Mfg Corp, 4607 Alger St, Los Angeles 39.**

Circle 328 on Reader Service Card

Liquid spring . . .

produces 40,000 lb force on ¼-in. stroke, 2½ in. dia and 5 in. long. Interior shock absorber action may be added. Spring rate is 120,000 lb per in. of deflection. **Taylor Devices, 188 Main St, N Tonawanda, NY.**

Circle 329 on Reader Service Card



Modern design toggle switch...

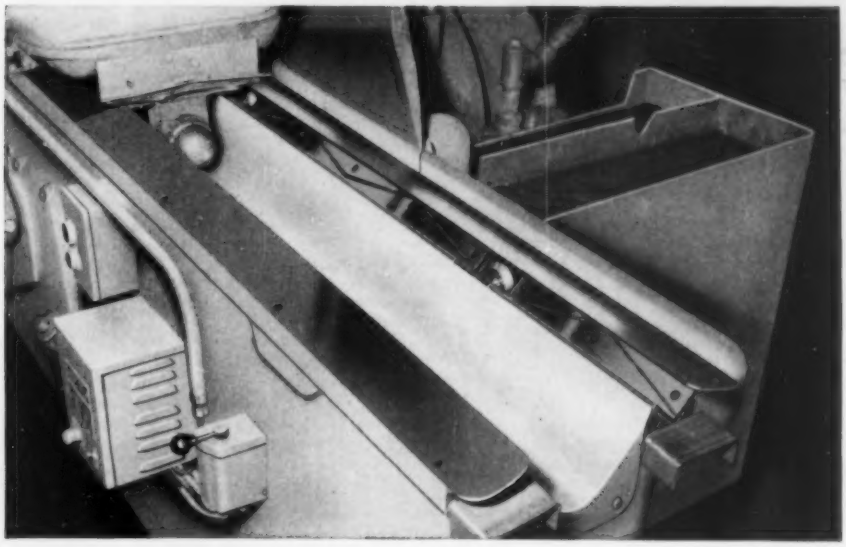
for control panels. Jam nut fastens ⅜ in. bushing. Design increases travel of bat

. . . CONTINUED ON PAGE 98

WEAR PLATES

ANOTHER *Lamina* BRONZE-PLATED PRODUCT

Lamina bronze–plated wear plates used on shaper ways.



Lamina bronze–plated wear plates used on grinder ways.

Lamina bronze-plated wear plates and their many uses are completely described in Bulletin WP-58. Send for your free copy.

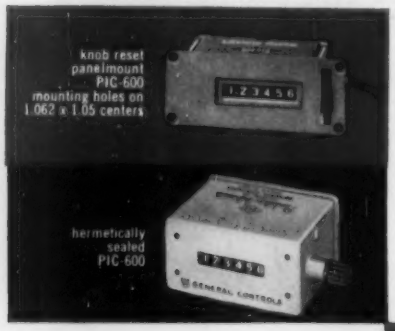
Lamina
DIES AND TOOLS, INC.
P.O. BOX 31, ROYAL OAK, MICHIGAN
Phone: JOrdan 6-8711

CIRCLE 97 ON READER SERVICE CARD

123 COUNTERS FOR ELECTRONICS AND INSTRUMENTATION

PIC-600 quiet electric counter offers great advantage for low level DC circuits - draws only .14 amperes from 30-volt transistor circuit.

QUIET OPERATION Efficient magnetic circuit and balanced mechanical action result in smoother operation with reduced noise



RECTIFIED FOR AC Eliminates AC hum—gives DC operating reliability from 25/40/50/60 cycles.

50 MILLION COUNT LIFE On life tests at 1000 cpm pass 100 million counts.

1000 COUNTS PER MINUTE Much higher speeds with suitable actuating impulses.

BALANCED ARMATURE Smooth, quiet operation and low friction in any position.

Also available to count dozens, coins, pairs, quads, etc.

TURNS COUNTER FOR POTENTIOMETER
Gives hundredth turn readings visible when fingers are on adjusting knob. Registers to 999 and repeats. Friction lock secures setting. Available with dial light and for remote operation.

INDEXING METER WITH SWITCH
Developed for use with wire and tape recorders. Switches are actuated automatically at fixed "index numbers" for which the unit is built. Many variations available for a wide range of application.

LOW BACK-LASH COUNTER ASSEMBLY
Rugged, add-subtract revolution counter assemblies widely used as indexing registers for potentiometers, variable capacitors and other digital readout requirements. Wide choice of optional features.

7-DIGIT REVOLUTION COUNTER
Non-reset. Adds or subtracts 10 counts per shaft revolution. Top-coming or top-going shaft rotation. Totally enclosed in die cast housing. Available sealed; also with adaptor for flexible shaft drive.

PIC GC

Manufacturers of Counters, Switches, Relays, Actuators and Automatic Valves

AUTOMATION CONTROLS DIVISION

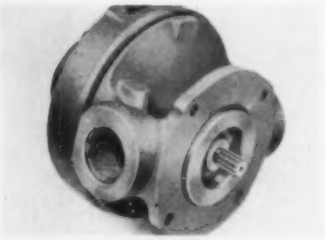
GENERAL CONTROLS CO.

8072 McCormick Boulevard, Skokie, Illinois

Representatives and Distributors in Principal Cities of United States and Canada

handle (50° compared with 30 to 35° on most toggles). Available in DPDT and 3PDT versions. Each circuit is rated 5 amp, 125 v ac; 4 amp, 30 v dc. **Electro-snap Corp, 4218 W Lake St, Chicago 24.**

Circle 330 on Reader Service Card



Hydraulic boost pump . . .

delivers min of 31 gpm at 3,450 rpm using MIL 5606 or 6083 fluids at 160 F. Operates with inlet conditions ranging from 125 psi to in excess of 18 in. hg. Mounted in direct drive. **Double A Products Co, Manchester, Mich.**

Circle 331 on Reader Service Card

Dual-bank counter . . .

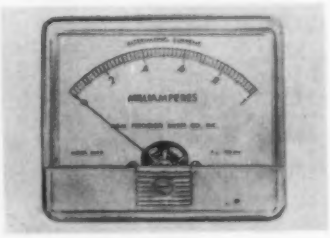
for machine tools and all digital readout equipment where plus and minus readings are needed. Available in right and left hand drives, clockwise and anticlockwise rotation; three, four or five digits. **Durant Mfg Co, 1938 N Buffum St, Milwaukee 1.**

Circle 332 on Reader Service Card

Low-torque pulse counter . . .

activated by stepping motor. Can be turned up to 40 counts per sec. Standard unit has six drums. **Haydon Instrument Co, Waterbury 20, Conn.**

Circle 333 on Reader Service Card



All-purpose panel meter . . .

is 6-in. Range of scales available. D'Arsonval movement is reported to achieve accuracy of 2% of full scale deflection. **Ideal Precision Meter Co Inc, 126 Greenpoint Ave, Brooklyn 22, NY.**

Circle 334 on Reader Service Card

Anodized nameplates . . .

custom-made in all sizes, designs, and in one or more colors. Aluminum plates are

(Continued on page 103)

"Customeered" components basic to industry

ideas on "Customeered" RUBBER PARTS

...their design and application for improved product performance **No. 1**

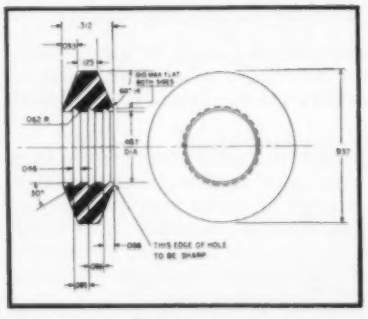
New ORCO continuous process now custom molds precision rubber parts in volume—at less cost!

Precise tolerances within ±0.003 in. are now possible in large volume production of custom-molded rubber component parts. Ohio Rubber's new high-speed, continuous molding process produces such parts at rates of up to 200,000 pieces per day.

Greater precision, which results in important savings on finishing costs, is assured through use of single-cavity, self-registering molds. They permit accurate, uniform application of pressure to minimize flash—maintain consistent tolerances for all dimensions. Uniform material thickness is equally assured by a plasticizing mill, which as an integrated part of the process directs uniform charges to each mold.

Direct feeding, from the mill to the mold wheel, eliminates the conventional intermediate extrusion step and further insures part uniformity and quality consistent with specifications. The continuous process permits *precise* control of time and temperature for each part.

Wide range of parts being more economically produced through Ohio Rubber's new molding process include (top, left to right): valve stem deflector, condenser seal, (bottom) seal piston rod packing, universal joint seal, and oil seal. These, like all the many other small, *precision* parts already produced or being produced, vary in dimensions up to 1½" in diameter and 1" in thickness.



High-precision is indicated in the close tolerances of this quadruple-landed seal for auto shock absorbers—more economically produced in volume through Ohio Rubber's new high-speed, continuous molding process.

Large volume production results in substantial cost savings for small, precision parts requiring tolerances obtainable by other precision molding processes. For parts formed by less precise, conventional methods, performance can be improved through greater accuracy—and without prohibitive increase in cost.

Quantity requirements involving 500,000 or more parts annually are recommended for most advantageous use of the new process. Since two similar parts of different size can be produced simultaneously by alternating the molds on the molding wheel, lower production runs which might not be economical can be combined with a separate order.

Complete information on this revolutionary new process is available in bulletin form. Send for your free copy today. At the same time, be sure to inquire about Ohio Rubber's complete component "Customeering" service—molding, extruding, and bonding-to-metal. Just mention ORCO Bulletin 715.

9DE1

THE OHIO RUBBER COMPANY

WILLOUGHBY, OHIO

A DIVISION OF THE EAGLE-PICHER COMPANY

CIRCLE 99 ON READER SERVICE CARD 99

... *between the Limitations of Single Metals with*

GENERAL PLATE CLAD METALS

The performance of a single metal will go so far . . . *but frequently not far enough.* And to bridge the gap between the limitations of single metals and the desired results, clad metals are used to obtain the requirements, or to do the job better . . . often at lower cost. That's why manufacturers of all types of products turn to General Plate for recommendations on their metal requirements. For instance . . . for electrical spring manufacturers, General Plate has developed:

Bronco*, phosphor bronze double-clad on copper to provide higher electrical conductivity without increasing cross-sectional area of spring blades.

Conflex* hardenable steel clad on one or both sides with sheet copper to obtain a superior spring material with better electrical conductivity and greater strength — at lower cost — than comparable copper alloys. And the copper surface is excellent for electroplated finishes.

Spring Tempered Stainless Clad Copper for spring blade service in applications requiring high electrical conductivity and excellent resistance to various types of corrosion.

If you are seeking metals with useful characteristics that can't be found in a single metal or alloy, investigate clad metals. If you want stronger or lighter components — or better electrical and mechanical properties — or fewer corrosion problems — or if you are interested in conserving critical metals or reducing parts costs, you can profit by using General Plate Clad Metals.

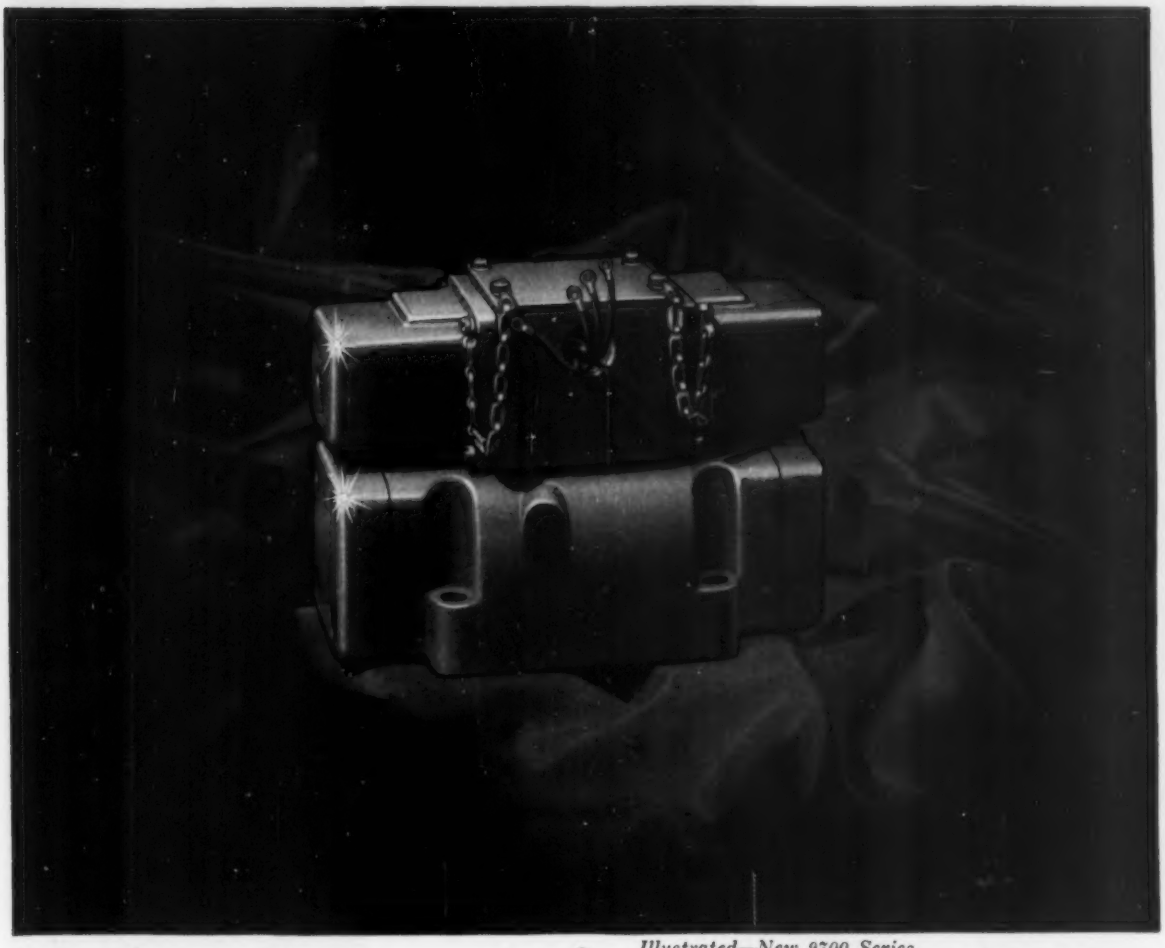
Write for a General Plate catalog today. Or better yet, why not talk over your requirements with a competent field engineer. His knowledge of the applications of clad metals is yours for the asking. No obligation, of course.

*Reg. Trade-Mark U.S. Pat. Off. and Foreign Countries

You Can Profit with General Plate Products . . .

METALS & CONTROLS
1010 FOREST STREET, ATTLEBORO, MASS., U. S. A.
A DIVISION OF TEXAS INSTRUMENTS INCORPORATED

GENERAL PLATE DIVISION: Clad Metals • Electrical Contacts • Truflex® Thermostat Metal • Platinum Metals • Reactor Metals • Radio Tube & Transistor Metals



Illustrated—New 9700 Series
Piggy Back Hydraulic Control Valve
Meets J.I.C. Standards

Look to Logan

the ultimate in hydraulic valve design

FREE SEND FOR THE "LOGAN CALCULATOR"
A gift to you from Logansport Machine Company upon request.

MEMBER: Natl. Mach. Tool Builders Assn.; Natl. Fluid Power Assn.

LOGANSPORT MACHINE CO., INC.
812 CENTER AVENUE, LOGANSPORT, INDIANA

PLEASE SEND COPY OF CATALOG:

- ☐ 100-1 AIR CYLINDERS
- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
- ☐ 100-5 LOGANSQUARE CYLINDERS
- ☐ 100-5-1 ULTRAMATION CYLINDERS
- ☐ 51 PRESSES
- ☐ FACTS OF LIFE
- ☐ 62 SURE-FLOW PUMPS
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLINDERS
- ☐ 200-3 750 SERIES HYD. CYLINDERS
- ☐ 200-4 and 200-7 HYD. VALVES
- ☐ 200-6 SUPER-MATIC CYLS.
- ☐ 70-1 CHUCKS
- ☐ ABC BOOKLET
- ☐ CIRCUIT RIDER

TO:

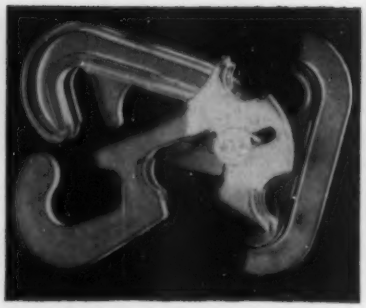
NAME_____ TITLE_____

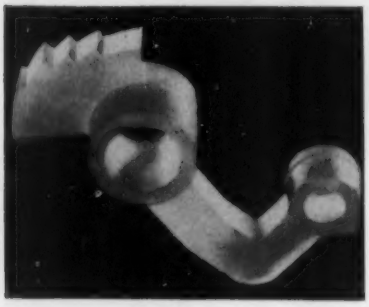
COMPANY _____

ADDRESS _____

5 ways to design for profit with Chicago Molded plastic parts

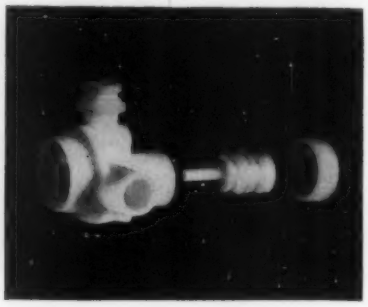
1 Nylon replaces metal in this idling cam. made by Chicago Molded for Holly Carburetor. By injection molding it of nylon, CMPC eliminated 3 operations—hardening, stamping, and assembly . . . cut production costs 50%. A unique mold design provides for easy changes in the number and sizes of ratchets at minimum expense. By any measure of value analysis, this is *designing for profit.* Think how this foresight could benefit your product, your profit.



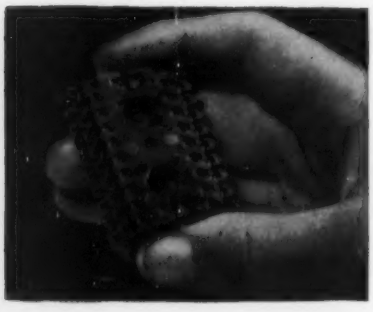


2 This molded plastic suspension clamp, used for spacing power cables, has installation-ease and maintenance savings designed into its 4 integrated acrylic parts. The two-piece clamp body is fastened securely with a special bolt and nut, also acrylic. Injection molded, the clamp saves up to 60% of the cost of conventional systems—another example of designing for profit with plastics by CMPC.

3 Linear polyethylene replaces brass in this deep-well component injection molded by Chicago Molded for Red Jacket Manufacturing Company. By applying the right plastic material and molding method, CMPC solved a long standing corrosion problem and improved pump efficiency. Cost—a fraction that of brass with finishing eliminated. Perhaps you have a similar part or component.



4 These injection molded nylon shapes compose a unique Venturi Valve unit used to regenerate the mineral bed of a Culligan Water softener. Previously, they were brass. By switching to Chicago Molded Thermoplastics, performance and durability were improved, material cost cut, machining and finishing eliminated. Your job may be smaller or very large, may require a different plastic, compression or transfer molding. For the right combination, call CMPC.



5 This transfer molded part is one of 10 Tormat memory blocks in the Seeburg Selectomatic 200 phonograph. The Chicago Molded body involves closest tolerances at 10 key spots on each side of the blocks. Fine detail and dimensional stability, good dielectric properties and high moisture resistance were basic material requirements met by CMPC. Our engineers can suggest ways to make your products better by designing in plastics . . . *designing for profit.*

DESIGN FOR PROFIT by consulting Chicago Molded engineers before committing your product to final drawings. They can show you how to make a good product even better, at lower cost through the use of custom molded plastic parts. Contact:

CHICAGO MOLDED
PRODUCTS CORPORATION
1024 North Kolmar Avenue, Chicago 51, Illinois

available with various types of adhesives. **Allied Decals Inc**, 8100-84 Hough Ave, Cleveland 3.

Circle 335 on Reader Service Card

Rotary transducer . . .

is electromechanical unit with variable permeance circuitry. 10-turn model operates on 400 cps. Operates —65 to 500 F. Linearity is 1%; phase shift ± 15° max. **Crescent Engineering & Research Co**, 5442N N Peck Rd, El Monte, Calif.

Circle 336 on Reader Service Card

1/8 through 1/50 hp motor . . .

has stamped steel case and exposed laminations. Measures 4¼ in. dia. Available in four and six-pole design; with internal fans, and totally enclosed or open ventilated. Suitable for applications in heating, ventilating, refrigeration and appliance industries. **Redmond Co, Owosso, Mich.**

Circle 337 on Reader Service Card

Pocket-size circular . . .

slide-rule performs multiplication, division, combined multiplication and division, fractions, squares, square roots, cubes, cube roots, proportions, percentages, areas and circumferences. Measures 3½ in. dia. $4.95 ppd. With carrying case. **Edmund Scientific Co, Barrington, NJ.**

Circle 338 on Reader Service Card

Precision resistor kit . . .

contains necessary tools, materials and instructions for winding prototype quantities of precision resistors. Replacement supplies are available. **Resistron**, 2487 E Washington St, Pasadena, Calif.

Circle 339 on Reader Service Card

Portable drafting machine . . .

for 12 x 18 in. drawing sheets consists of three demountable units, a board, a parallel arm assembly and protractor with scales. 15 x 20 in. masonite board is equipped with three circular paper clamps. Four 13-in. long arms and off-corner mounting combine to cover board surface with vertical and horizontal scales. Protractor reads 90° each side of zero. 10-day trial period. Price, $12 with board. **Drafting Equipment Co**, 504 Randolph St, Meadville, Penna.

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Low-cost hydraulic power! The CircuitPak prices hydraulic power competitively with air power, for clamping, indexing, pressing, drilling, welding, etc. Get the precise control and pressures you need, with CircuitPak.

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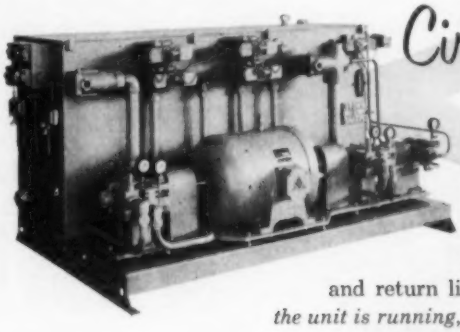
Double A Hydraulic Power Units



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The unique L-shaped CircuitMaster design cuts external piping 40% or more, eliminates separate panels and manifolds. Every component is easily reached. Fluid from individual drain and return lines may be observed *while the unit is running*, for faster trouble-shooting.

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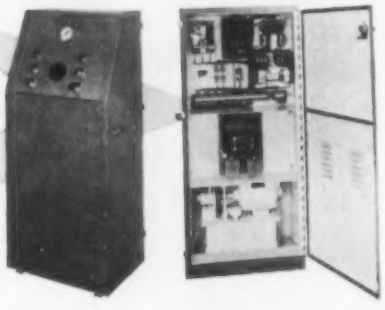
Double A builds complete hydraulic-power and electric-control packages, providing one-stop shopping for the equipment builder.



Take advantage of Double A hydraulic developments. Contact your nearest Double A hydraulic distributor. Or write to **Double A Products Co.**, a subsidiary of Brown & Sharpe Mfg. Co., Manchester, Michigan.

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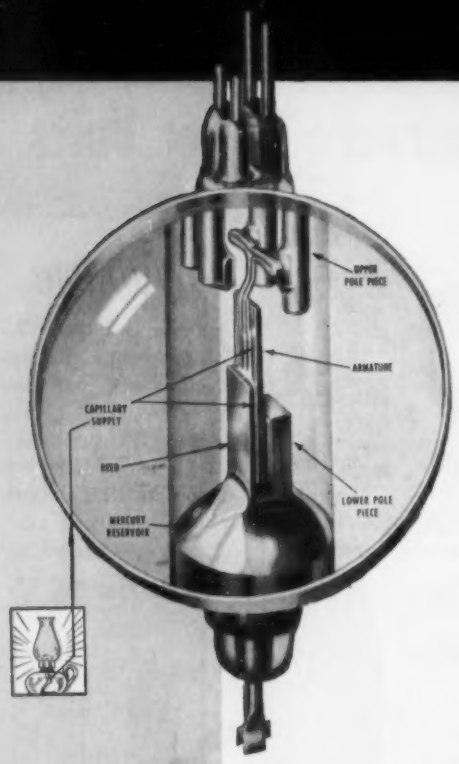
CLARE Mercury-Wetted

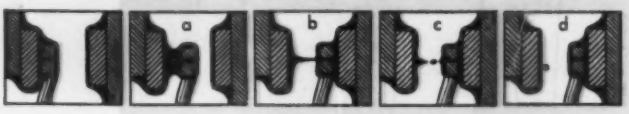
*with contact load of 250 volt-amperes.



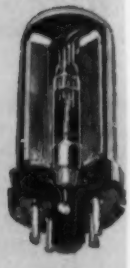
NEVER WEAR OUT

Longevity is built into these relays. The basic magnetic switch is sealed in a glass capsule filled with pressurized hydrogen. With every make and break the mercury-film contact surface is renewed . . . by capillary action, like a lamp wick. These contacts never get dirty, never lock or weld and *NEVER WEAR OUT.*

NEVER CHATTER OR BOUNCE



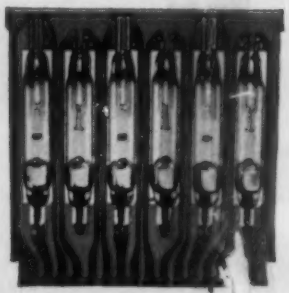
Contact closure between the two liquid surfaces bridges any mechanical chatter and prevents its appearing in the electrical output. (a) Filament of mercury forms between the contacts as they separate. (b) This becomes narrower in cross section and (c) finally parts at two points, allowing a globule of mercury to fall out. (d) The extremely fast break minimizes the arc and adds greatly to contact load capacity.



NO MAINTENANCE REQUIRED

HG Relay cutaway to show magnetic switch surrounded by operating coil and encased in a metal housing.

HGS Relay cutaway to show biasing magnets attached to the ends of the side plates.



HG6F Relay printed circuit panel showing six in-line mercury-wetted contact switches mounted in minimum space.

With all working parts sealed and switches and coils enclosed in metal housings, these relays are tamper-proof and always in constant adjustment. They require no maintenance whatsoever.

–with no maintenance!

Contact Relays on test 4 years

A FULL LINE OF THE MOST RELIABLE, MOST DURABLE RELAYS EVER MADE

single form D

Type HG. Capable of up to 100 operations a second. Load-handling capacity to 5 amperes and up to 500 volts. (250 va max. with proper contact protection.)

single form D

Type HGP. Can be factory adjusted to provide single side-stable, bi-stable or chopper characteristics.

single form D

Type HGS. Biased with permanent magnets. Speed up to 200 cps. Sensitivity as low as ±2.5 milliwatts. Handles up to 2 amperes, up to 500 volts (100 va max. with proper contact protection.)

four form D

Type HG4. Four form D switches enclosed in a single housing with coil. Plug-in assembly (shown) is standard. Other mountings available.

two or three form D

Types HG2 and HG3. Two or three form D Switches enclosed in a single housing. HG2 has 8 or 11-pin octal style plug. An 11-pin base is standard for HG3.

six in-line flat pack

Type HG6F. Six switches mounted in line on printed circuit panel surrounded by single coil. Flat, compact assembly. Over-all dimensions: 3.640" x 3.125" x 1.046". Uses standard 32 or 36 terminal printed circuit socket.

For complete information on CLARE Mercury-Wetted Contact Relays or on the entire CLARE line of superior relays and electronic components address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Limited, P. O. Box 73, 2700 Jane Street, Downsview, Ontario. Cable Address: CLARELAY.

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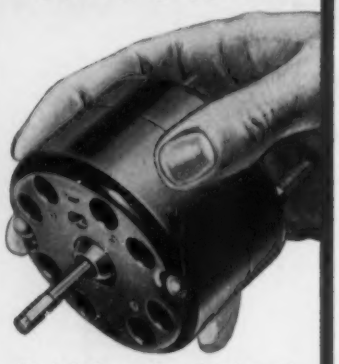
that meet the demands of the most exacting requirements



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MODEL	HP 1500 RPM	Locked Torque in./oz.	Max. Torque in./oz.	Free Speed RPM	Wt. Lbs.
B-5-CW B-5-CCW	1/80	3.5	11	1735	2.0
B-8-CW B-8-CCW	1/50	4.0	14	1750	2.7
B-10-CW B-10-CCW	1/40	4.7	18	1750	3.1
B-12-CW B-12-CCW	1/35	4.7	20	1760	3.4

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 117.

SERVO MOTORS—Catalog, 16 pp. Contains electrical and mechanical specs, dimensional drawings, schematics and torque-speed curves on size 15 servo motors. Helipot Div, Beckman Instruments Inc, 2500 Fullerton Rd, Fullerton, Calif.

Circle 341 on Reader Service Card

SMALL BASIC SWITCHES—Catalog 63, 20 pp. Covers four groups and typical auxiliary actuators and assemblies with each of four types. Contains specifications on about 100 units. Micro Switch, Freeport, Ill.

Circle 342 on Reader Service Card

FLEXIBLE CUSHION COUPLINGS—Bulletin 669C, 12 pp. Describes expanded line, ranging from fhp to 190 hp per 100 rpm. Photos, drawings and text explain design features and operating characteristics of couplings. Includes tables of hp ratings, prices, dimensions and service factors for many applications. Dodge Mfg Corp, Mishawaka, Ind.

Circle 343 on Reader Service Card

INSTRUMENT AND ELECTRONIC COMPONENTS—Catalog 20a, 416 pp. Consolidates all previous catalogs and supplements, listing over 10,000 items available from stock. With specifications and prices. Contains separate technical information, breadboard kit and precision tool components section. Pic Design Corp, 477 Atlantic Ave, East Rockaway, NY.

Circle 344 on Reader Service Card

RIGID PLASTIC PIPE—Bulletin CE-80, 16 pp. Covers sizes, weights and rated pressures for chemical-resistant, non-toxic, odorless pipe, fittings and valves. American Hard Rubber Co, Div Amerace Corp, Ace Rd, Butler, NJ.

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CENTRIFUGAL BLOWERS—Catalog, 12 pp. Illustrates typical single blower units and features 54 flow charts, electrical specs and dimensions on blowers that cover frequencies from 60 to 1000 cps with free air ratings from 18 to 270 cfm. Air-Marine Motors Inc, 369 Bayview Ave, Amityville, NY.

Circle 346 on Reader Service Card

WELDED STEEL TUBING—Catalog, 12 pp. Describes characteristics and features of welded steel tubing. Covers size and gage in chart form. Revere Copper & Brass Inc, Rome Mfg Co Div, PO Box 111, Rome, NY.

Circle 347 on Reader Service Card

INDUSTRIAL FANS—Bulletin L-5, 28 pp. Fundamental data on capacities and construction of fans includes rating tables, correction ratios for deviations from standard atmospheric conditions. Lehigh Fan & Blower Div, Fuller Co, Catasauqua, Penna.

Circle 348 on Reader Service Card

JOURNAL AND THRUST BEARINGS—Catalog W-1, W-2, 4 pp each; W-3, 14 pp. Represents line of bearings in standard sizes. W-1 covers sliding journal bearings in sizes up to 45 in.; W-2 describes line of tilting pad journal bearings from 2½ through 12 in.; W-3 describes tilting pad thrust bearings from 4 through 45 in. Waukesha Bearings Corp, Dept R, Waukesha, Wis.

Circle 349 on Reader Service Card

PRINTED CIRCUIT CONNECTORS—Catalog SF-156 UPCC, 6 pp. Electrical and mechanical specs, dimensional drawings and basic design features of two-unit connectors. US Components Inc, 454 E 148th St, New York 55.

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TYPING SPECIAL SYMBOLS—Booklet R 8964.6, 12 pp. Tells how interchangeable typewriter type can be used in electric typewriters for typing of special symbols and equations. Remington Rand, 315 Park Ave S, New York 10.

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ADJUSTABLE-SPEED DRIVES—Bulletin D-2507, 12 pp. Gives performance and application information on line of all-electric, adjustable-speed drives covering typical applications from ½ through 4 hp. Condensed specifications, dimensions and a gear motor selection table are included. Reliance Electric and Engineering Co, 24701 Euclid Ave, Cleveland 17.

Circle 352 on Reader Service Card

CONTINUOUS AC-DC POWER—Bulletin B.21-200, 6 pp. Explains standby power system that changes from normal to emergency operation without appreciably

(Continued on page 109)

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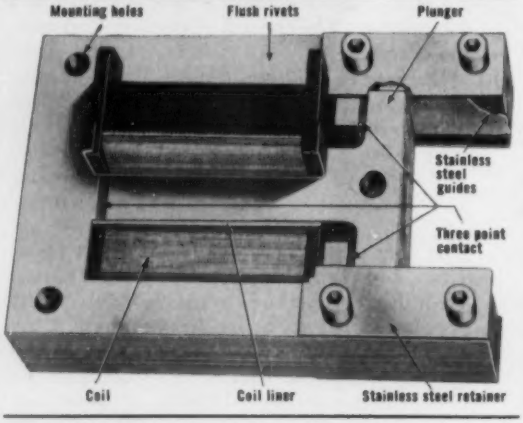

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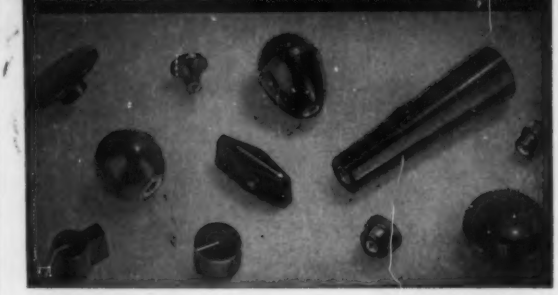

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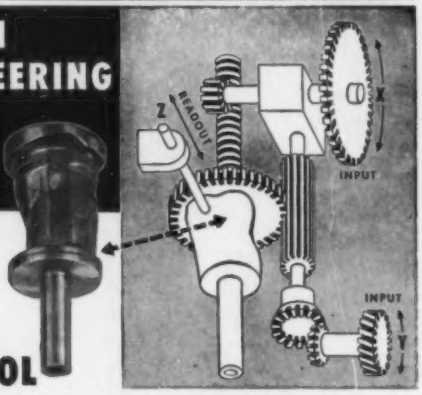

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PLASTIC RESINS—Catalog, 8 pp. Basic information on properties and applications of acrylonitrile-butadiene-styrene plastic resins. Marbon Chemical Div, Borg-Warner Corp, Box 68, Washington, W Va.

Circle 354 on Reader Service Card

SEMICONDUCTOR DEVICES—Condensed Catalog TE-1340A, 8 pp. Features, characteristics and ratings for silicon and germanium devices. Transitron Electronic Corp, Wakefield, Mass.

Circle 355 on Reader Service Card

TEXTURED METALS—Brochure, 6 pp. Contains descriptions, dimensions and general specifications of textured sheets and continuous coils. Ardmore Products Inc, 193 Aldene Rd, Roselle, NJ.

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CIRCUIT BREAKER—Booklet, 8 pp. Announces 2300 series circuit breaker. Gives specifications and construction details. Wood Electric Co, 244 Broad St, Lynn, Mass.

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MOTORIZED SPEED REDUCERS—Bulletin MSR-59A, 4 pp. Describes two-speed motorized speed reducers for increasing capacity of light-duty, belt-driven machines. Includes operating and installation characteristics, specs and ordering information. Pull-Gear Co, 25425 Mound Rd, Warren, Mich.

Circle 358 on Reader Service Card

ALUMINUM BRONZE BARS—Folder, 4 pp. Outlines advantages of solid and centrifugally-cast cored bars. Covers applications. Johnson Bronze Co, New Castle, Penna.

Circle 359 on Reader Service Card

SELECTIVE PLATING—Brochure, 4 pp. Describes process of electroplating selected areas without using immersion tanks. Sifco Metachemical Inc, 935 E 53rd St, Cleveland 3.

Circle 360 on Reader Service Card

SPOT WELDING FASTENERS—Bulletin 595, 6 pp. Gives dimensional information and illustrates typical applications. Presents welding recommendations for all parts. Ohio Nut & Bolt Co, 33 1st Ave, Berea, Ohio.

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(Continued on page 113)

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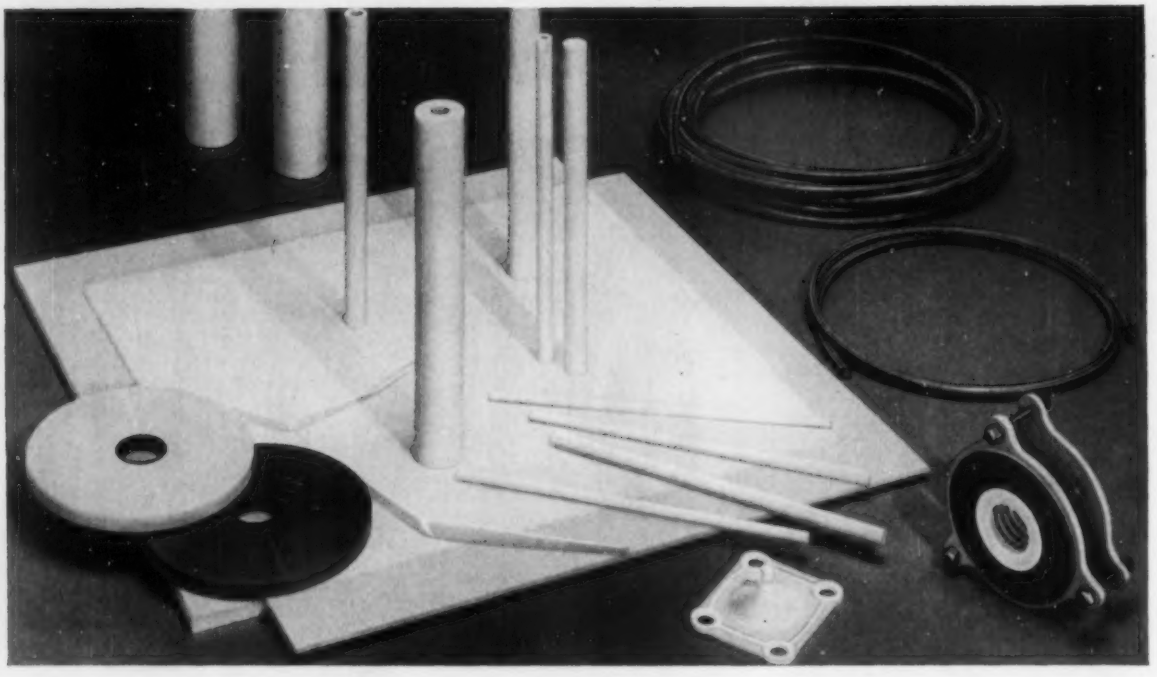

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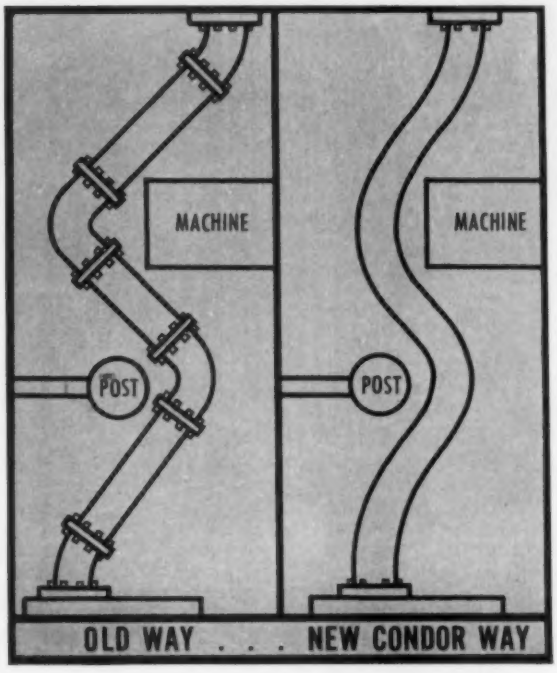

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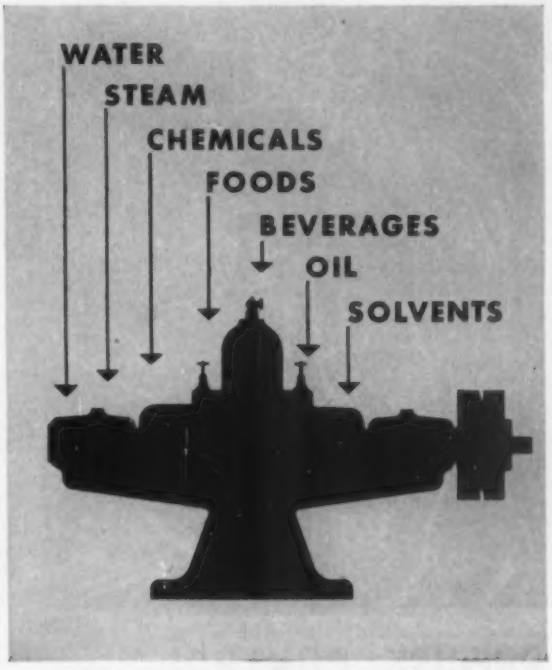

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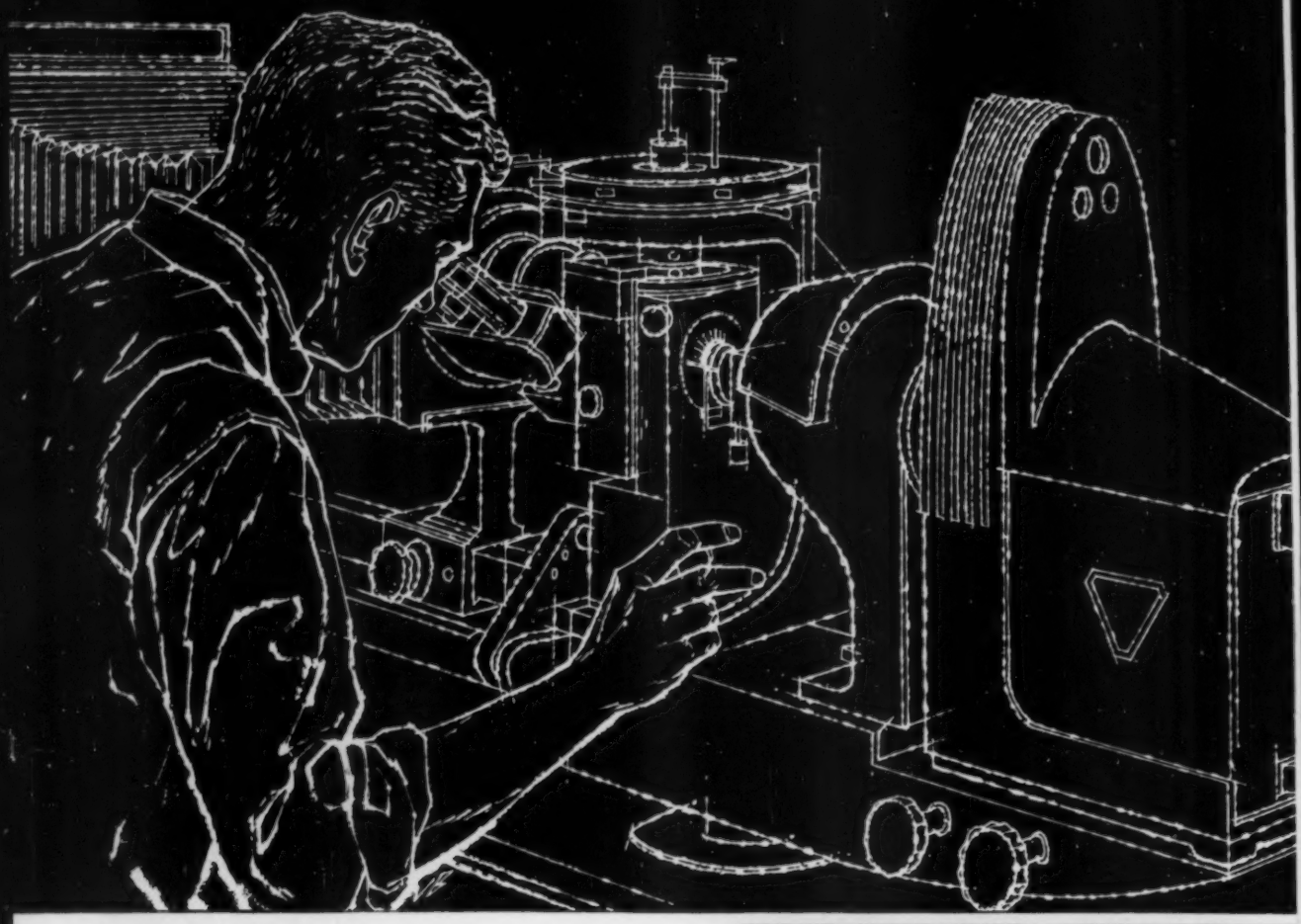

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tion and installation diagram for pump rated 200 gpm at 3000 psi. Texas Hydraulics Inc, 8500 Research Blvd, Austin, Tex.

Circle 362 on Reader Service Card

4-WAY AIR VALVE BASES—Bulletin 235, 4 pp. Covers alternate bases and integral speed control section for 4-way air valves. Discusses piping and variations now available. Hannifin Co, Dept 126, 501 S Wolf Rd, Des Plaines, Ill.

Circle 363 on Reader Service Card

GRAIN SIZE OF BRASS ALLOYS—Bulletin, 6 pp. Explains how selection of correct ultra fine grain size can reduce finishing costs. Bridgeport Brass Co, 30 Grand St, Bridgeport 2, Conn.

Circle 364 on Reader Service Card

CARBON STEEL TUBING—Bulletin TDC-142B, 4 pp. Furnishes condensed information on mechanical and physical properties of seamless and welded carbon steel pressure tubing. Babcock & Wilcox Co, Beaver Falls, Penna.

Circle 365 on Reader Service Card

PERMANENT MAGNETIC PULLEYS—Catalog 152-9, 6 pp. Discusses radial design and its application. Also featured is a selection chart, a table of pulley weights, capacities and dimensions. Magnetic Engineering & Mfg Co, 940 Van Houten Ave, Clifton, NJ.

Circle 366 on Reader Service Card

CONVEYOR AND ELEVATOR BELTS—Brochure, 4 pp. Specifications and applications for four types of rubber belting. Weight computation of belting is explained. Home Rubber Co, Trenton 5, NJ.

Circle 367 on Reader Service Card

BRAZING ALLOYS—Booklet, 8 pp. Discusses high-purity brazing alloys for copper, bronze or brass. Gives specs and cooling charts on standard alloy compositions for nonferrous brazing. Alloy Specialties Co, Swissvale, Penna.

Circle 368 on Reader Service Card

CONVEYOR AND POWER TRANSMISSION BELTING—Catalog, 8 pp. Includes descriptions, application information and illustrations of various available belting for manufacturing and food processing equipment. Voss Belting & Specialty Co, 5645 N Ravenswood Ave, Chicago 26.

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TEMPERATURE CONTROL SYSTEM—Bulletin PS-4A, 4 pp. Describes electromechanical system that automatically holds temperature of liquids, air or solids

(Continued on page 116)

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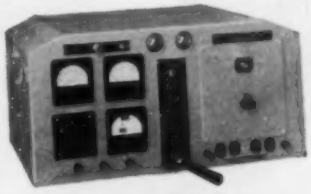

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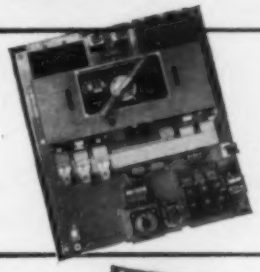

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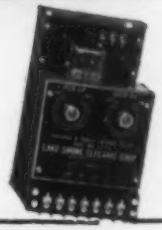
This compact safety transfer switch is of mechanically-linked dual circuit breaker design which permits no neutral position. Full relay protection. To 4000 amps, 600 volts.



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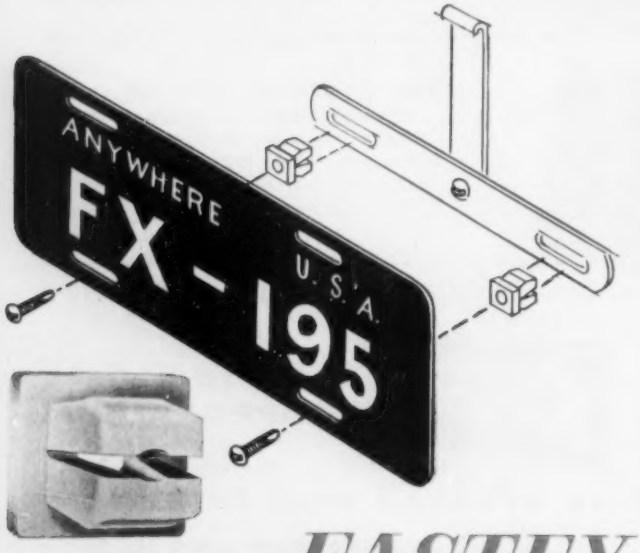

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within prescribed limits. Air-Borne Accessories Corp, 1414 Chestnut Ave, Hillside, NJ.

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SELF-CLEANING PIPELINE STRAINER–Bulletin 1210-1, 2 pp. Gives construction, dimensions, weights and ratings of strainers in sizes from ¼ through 3 in. Sarco Co Inc, 635 Madison Ave, New York 22.

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COLD HEADING WIRE–Bulletin, 4 pp. Describes applications and advantages, lists available tempers, gives characteristics and specifications. Scovill Mfg. Co, Mills Div, 99 Mill St, Waterbury 20, Conn.

Circle 372 on Reader Service Card

VANE-TYPE FUEL PUMPS–Bulletin A-5242, 4 pp. Design and performance characteristics of series of fixed-displacement, balance vane type fuel pumps for jet engines. Includes chart showing delivery rates, speeds, physical characteristics. Vickers Inc, Detroit 32.

Circle 373 on Reader Service Card

ALLOY MECHANICAL TUBING–Folder TB-430, 4 pp. Discusses initial cost, structural advantages, fabrication, types of steel, types of tubes and ordering information. Babcock & Wilcox Co, Beaver Falls, Penna.

Circle 374 on Reader Service Card

PHOTOELECTRIC MATERIALS HANDLING–Bulletin 593, 1 pp. Describes package sorting and merging system, applying measuring controls. Photomation Inc, 96 S Washington Ave, Bergenfield, NJ.

Circle 375 on Reader Service Card

PRINTING DEMAND METERS–Brochure GEA-6892, 8 pp. Describes line of redesigned printing demand meters. Discusses application, design and cost. General Electric Co, Schenectady 5.

Circle 376 on Reader Service Card

MAGNETIC CLUTCH–Data sheet, 2 pp. Offers general specifications, characteristics and special requirements of C-18 magnetic clutch. Guidance Controls Corp, 110 Duffy Ave, Hicksville, NY.

Circle 377 on Reader Service Card

STANDARD POWER SUPPLIES–Catalog sheet 100 A, 2 pp. Sets forth checklist of requirements for any supply problem. Presents prices, descriptions and specifications of line of standard power supplies. Burmac Electronics Co Inc, 142 S Long Beach Rd, Rockville Centre, NY.

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SOLENOID VALVE–Engineering data sheet FR 108, 2 pp. Lists operating specifications, performance data and dimensions of two-way pilot-operated solenoid valve. Includes typical flow curve. Fluid Regulators Corp, 313 Gillette St, Painesville, Ohio.

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HAND TACHOMETERS–Catalog 61, 4 pp. Gives sizes and ranges of models 1600, 3200, 4800, 1 HT and 3HT. Also prices and information on standard accessories. Jones Motrola Corp, 432 Fairfield Ave, Stamford, Conn.

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CARTRIDGE SELENIUM RECTIFIERS–Catalog, 8 pp. Contains descriptions, specifications and characteristics of line of glass or phenolic tube cartridge rectifiers. Shows dimensional outlines and circuit diagrams. Syntron Co, 240 Lexington Ave, Homer City, Penna.

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TANTALUM CAPACITORS–Bulletin 152D, 2 pp. Specifications and perform-

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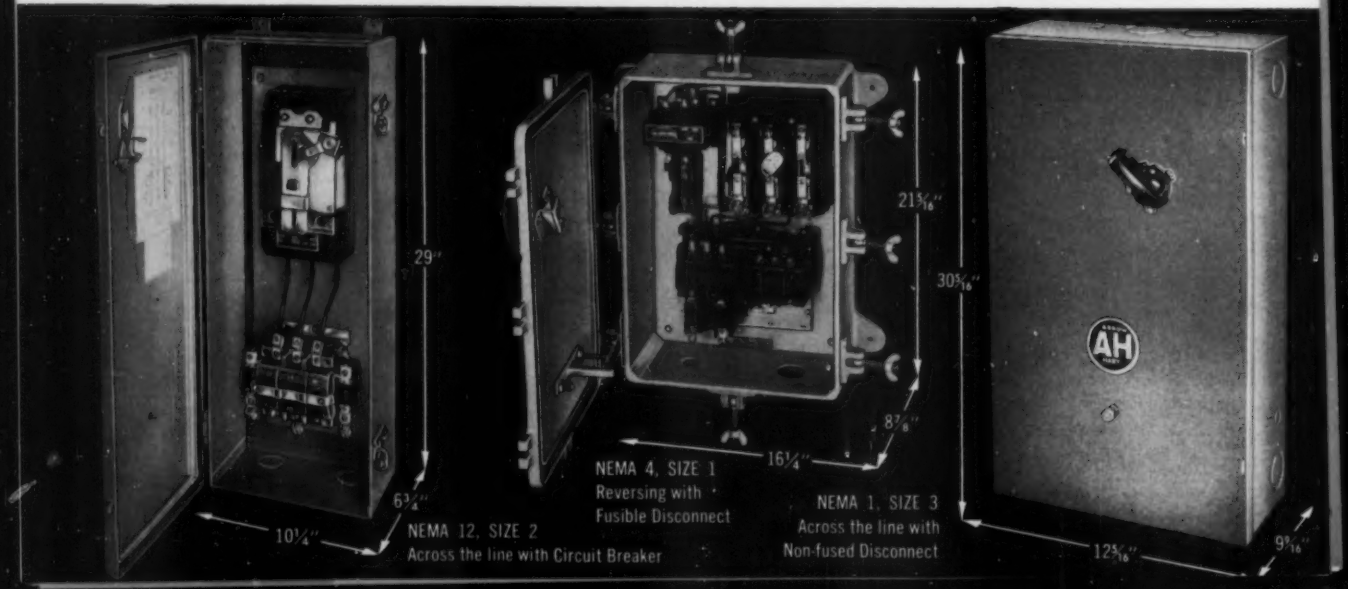

ance information on tantalum foil electrolytic capacitors. Ohmite Mfg Co, 3634 Howard St, Skokie, Ill.

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SYNCHRO DIFFERENTIALS – Data sheet 801-D4, 2 pp. Presents tables of electrical and mechanical specifications, dimensional and schematic drawings for size 8 units. Daystrom Transicoil Div, Daystrom Inc, Worcester, Montgomery County, Penna.

Circle 383 on Reader Service Card

TEFLON STOCK–Fact sheet 3, 4 pp. Gives sizes available, engineering data and typical uses of Teflon stock. Chemplastic Inc, 3 Central Ave, East Newark, NJ.

Circle 384 on Reader Service Card

COLLETS AND FEEDERS–Catalog 23, 24 pp. Describes and illustrates collets and feeders for use on machine tools and other types of machinery. Sutton Tool Co, Sturgis, Mich.

Circle 385 on Reader Service Card

ARMATURE DRIVE–Brochure P-68, 4 pp. Covers operation, dimensions, replacement parts and installation of spline drive armature assembly for heavy-duty applications. Warner Electric Brake & Clutch Co, Beloit, Wis.

Circle 386 on Reader Service Card

ULTRASONIC TECHNIQUES–Bulletin 259, 6 pp. Discusses techniques and applications possible with ultrasonic homogenizers. Describes new machine and illustrates several operations. Sonic Engineering Corp, 146 Selleck St, Stamford, Conn.

Circle 387 on Reader Service Card

DIELECTRIC MATERIALS – Short form catalog, 8 pp. Contains condensed listing of line of dielectric materials. Center chart gives data on various standard resins. Emerson & Cuming Inc, Canton, Mass.

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Letterhead Requests Only

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

POWER DRIVE CALCULATOR–Slide rule. Computes proper roller chain for every type of drive. Six slide rules are combined into one calculator. Offered to engineers responsible for design and specification of roller chain drives. Atlas Chain & Mfg Co, Dept C, West Pittston, Penna. Penna.

VIBRATION ISOLATION MATERIAL –Technical manual, 44 pp. Contains reference charts and text developed by laboratory tests conducted over a period of many months. Aids in use of preformed fabric-neoprene and rubber pad materials to solve objectionable vibration and shock conditions. Voss Engineering Inc, 5649 N Ravenswood Ave, Chicago 26.

VARIABLE-SPEED DRIVES – Catalog M-592, 96 pp. Explains assortment of styles, modifications and accessories available in capacities from ¼ through 40 hp. Includes construction features, specifications, speed and rating tables and prices. Reeves Pulley Div, Reliance Electric and Engineering Co, Columbus, Ind.

SEMICONDUCTOR INDUSTRIAL RECTIFIERS–Technical paper, 6 pp. Gives basic explanation of uses and types of industrial rectifiers and covers such topics as monitoring and indicating of failures, current and voltage balance, overload protection, voltage surges, cooling, efficiency and power factor. Perkin Engineering Corp, 345 Kansas St, El Segundo, Calif.

MINIATURE SCREWS–Catalog, 4 pp. and price list. Describes inventory of miniature machine screws. Includes table of screw dimensions. Hardware Specialty Co Inc, 479 Washington St, New York 13.

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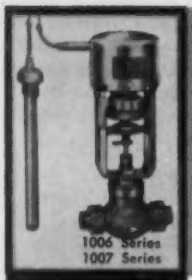

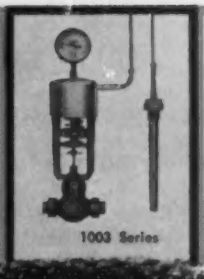

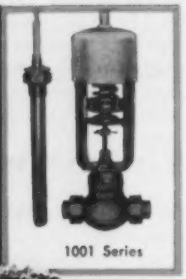

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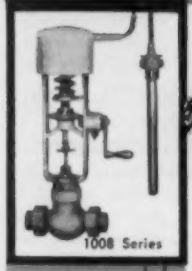

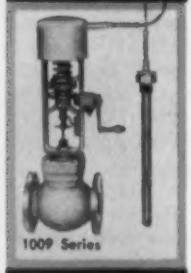

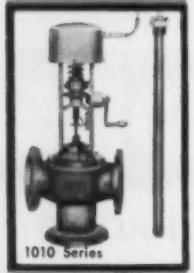

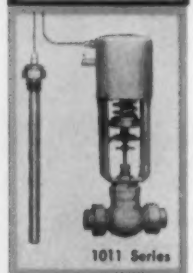

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1006 Series-1007 Series: Fail-safe; damage to thermal system automatically opens or closes valve as required. 30°F. adjustable ranges, −50 to 325°F. Valve sizes (1006): ¼"-¾" single; ¾"-2" double — (1007): ¼"-2" single; ¾"-4" double; ¾"-3" three-way.

1008 Series: Crank provides quick adjustment of control point. Same characteristics and valve sizes as 1003. Thermometer optional.

1009 Series: Crank for manual positioning of valve during start-up or abnormal conditions. Same characteristics and sizes as 1003. Thermometer optional.

1010 Series: Our biggest regulator . . . designed exclusively for 3" through 6" three-way valves. Manual valve positioner.

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Practical guide to ways that will give the specific coating needed. Sept. 28
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List of helpful modern methods, materials and equipment that save money. Sept 28
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Three-step method chooses type and rating for power and control. Sept. 28
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How eye-catching color code conveys information from machine to operator. Sept 14
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Properties of air under pressure. Curves useful from 0 to 12000 psi and −150 to 250 F. Sept 14
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(Continued on page 120)

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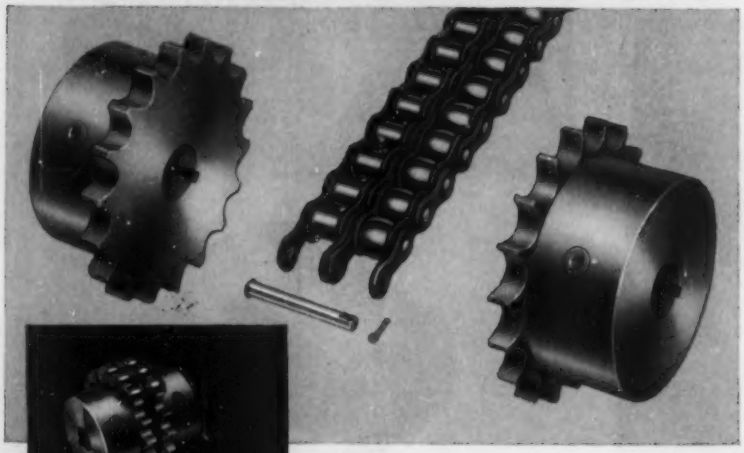

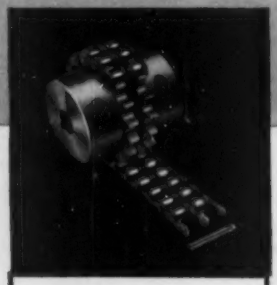

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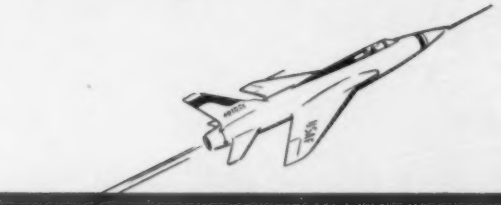
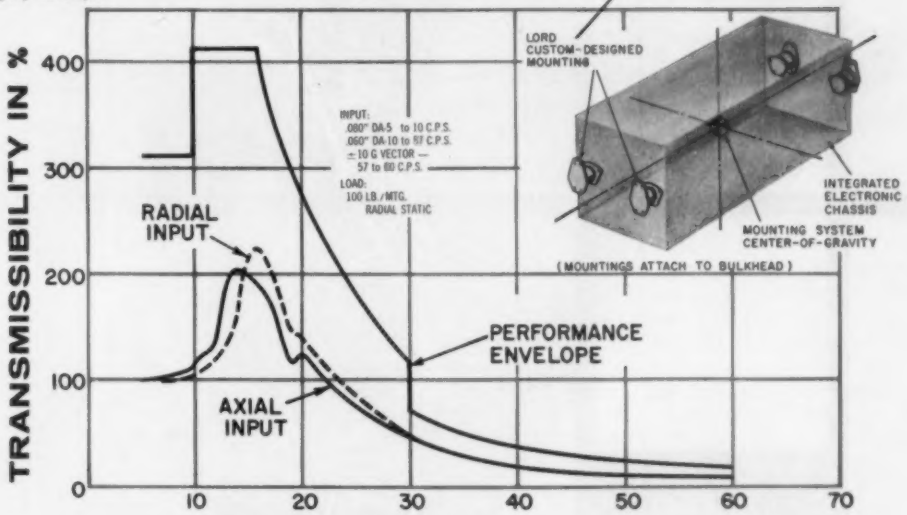


Vibration/shock/noise control—Two integrated electronics chassis on Republic F-105 jet fighter are mounted on special Lord high-performance isolators. Severe environment includes vibration, superimposed sustained accelerations to 9 G and 30 G shock loads throughout temperature range from — 65° to + 200° F.

In final design shown, four isolators weighing less than 1.5 pounds each support chassis weighing between 266 and 400 pounds. Use of Lord BTR (Broad Temperature Range) elastomer assures excellent damping plus constant performance over wide temperature range.

Transmissibility curve shows how efficient vibration isolation keeps equipment well inside fragility envelope.



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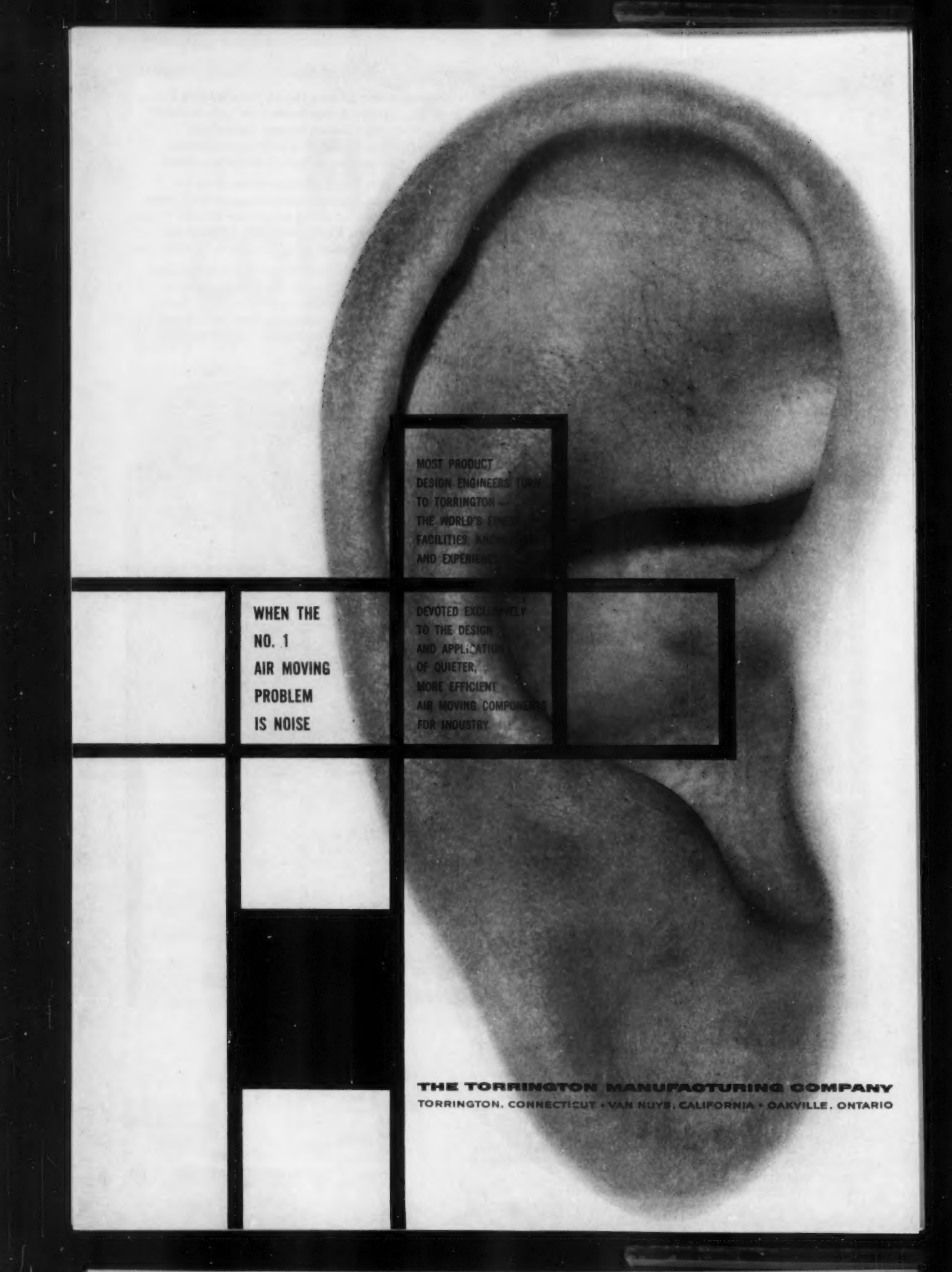
CIRCLE 121 ON READER SERVICE CARD 121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TO TORRINGTON
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WHEN THE
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PROBLEM
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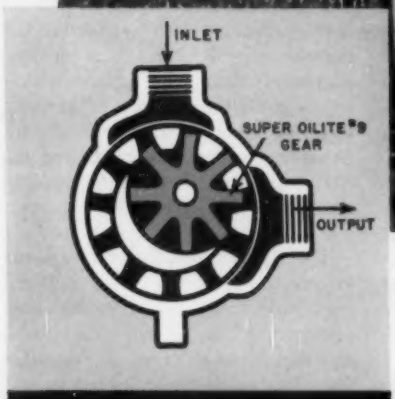

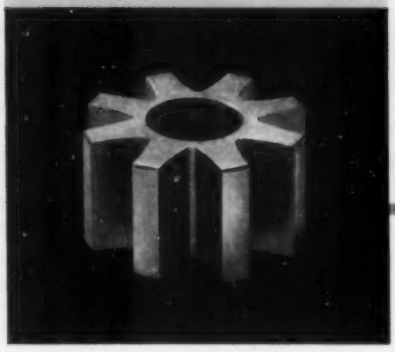

Double Sprayer Output, Cut Costs 75% with Oilite Precision Gear

The search for a more durable star gear at less cost led Hahn, Inc., Evansville, Indiana to investigate Amplex powder metallurgy. Amplex engineers came up with an answer that far exceeded Hahn's expectations.

Formerly machined from cast bronze, the gear is now produced in a single press operation of hardened Super Oilite No. 9†. By eliminating scrap and machining operations like turning, boring, cut-off and hobbing, Amplex reduced the cost of the gear approximately 75%. But that's not all . . .

Despite exposure to acid-forming, gritty fertilizers and pesticides, the oxide-coated Oilite gear proved 5 times more durable than its predecessor! Tough Super Oilite No. 9 proved so remarkably wear-resistant, Hahn was able to double the pump's gpm output.

What do *you* look for in components—lightweight, close tolerances, corrosion resistance, wear resistance or superior surface finish? Amplex can supply quality-controlled parts in volume that meet *all* of these requirements.

To put superior performance at less cost into your products, contact the nearest Oilite Engineer. Look for him in the Yellow Pages under "Bearings" or write Department A-10.

† Only Chrysler makes Oilite

QDP or PDQ?*

Why risk excessive production and warranty costs? You can depend on Amplex for top *quality* components, prompt *delivery* and a reasonable *price* . . . QDP! The result is parts that reduce your manufacturing and selling costs.

* Quality-Delivery-Price vs. Price-Delivery-Quality

SINCE 1929 — A CHRYSLER OILITE PRODUCT

the most trusted name in powder metallurgy!

AMPLEX DIVISION

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PRECISION PARTS • SELF-LUBRICATING BEARINGS • METAL FILTERS • FRICTION UNITS

CIRCLE 122 ON READER SERVICE CARD

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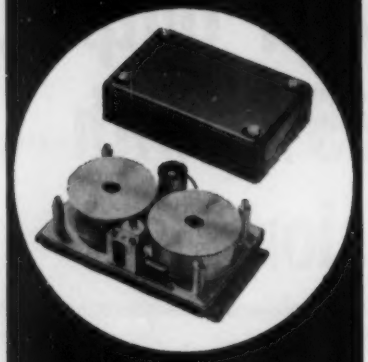


160 feet of punched Mylar tape is accommodated in the new Beattie-Coleman MLPR-13 Programer, providing a completely random program of 252 minutes duration on 13 channels. Extremely accurate time control with no cumulative error. Available in five speeds: ¾", ⅜", ¾", 1½", and 3" per sec. Weighs less than 5 lbs., is easily removable for loading. Programs can be initiated or altered in a few minutes. Compatible with most missile guidance systems.

Write for complete data on the MLPR-13 and other multi-channel Beattie-Coleman Programers for either repeat cycling or random operation.

BEATTIE-COLEMAN inc.
1000 N. Olive St., Anaheim, California
Branch: 437 Fifth Avenue, New York, N. Y.

tangents...

Did Popov Invent Radio?

Hundreds of Americans were startled, then derisive, at the recent Soviet Exhibition, to see a bust of A. S. Popov labeled as "the inventor of radio," together with a model of his set and copies of supporting documents. What happened to Marconi?

Did Popov invent radio, or is this just another attempt to seize credit for the USSR? Let's dig back a little and see.

After Clerk Maxwell theorized on waves, Hertz demonstrated the existence of radiation in 1887. This was the real beginning of radio. Rutherford and others were working on the problem, and several achieved about the same level of development at about the same time. Popov demonstrated a crude receiver May 7, 1895, but went no further with it himself, although he did predict transmission by means of oscillations. Marconi perfected a working apparatus at almost exactly the same time in Italy, and transmitted over a mile. By the next year, he had transmitted nine miles and received an English patent on his invention. Just a year after that —in 1897—he had established his own company and begun commercial exploitation. He transmitted across the Atlantic Dec 1, 1901, on his first try.

This was not all luck or poor communication between nations. Marconi, who had an English mother and independent means, took his idea to England and developed it. He hired two well-known physicists, Lodge and Fleming, to work on it, and they developed essential parts. Thus the credit has gone to Marconi for perfecting a workable apparatus and for demonstrating radio's potentials over a reasonable distance. Meantime, Popov and various other inventors were still talking about it. As a matter of fact, the Soviets themselves admit that the only practical application of Popov's work was made by a Frenchman some time later.

Another case in point is Novikov gearing, recently promoted by the Russians as a dramatic new design, but apparently quite similar—if not identical—to Ernest Wildhaber's patent of two decades or more ago. An appraisal of world opinion on this tooth shape appeared recently in PE.

These incidents of course dramatize the frequent occurrence of "simultaneous invention" based on known principles. The same arguments have been waged over the air brake, the steamboat, and many other devices. Arguments then—and arguments now —center on the first arrived at some stage of demonstrable development. Actually, however, the credit and the cash always go eventually to the man who makes his invention a commercial success.

The Russians are driven by a desire to compare favorably with the Western world, and this has led their heirarchy to make sweeping claims and supply what to us are distorted statistics. Some are distorted in any light. They arise from the Russian tendency to suppress unfavorable figures—the actual wages of the lowest-level Soviet workers, the actual number of older people who are illiterate, the problems of seeking employment for the new worker. Existence of statistical data on such problems is denied to permit sweeping claims. Other statistics just aren't available, or are figured on a different base than ours, so comparison is at best dangerous, at worst meaningless. How can prices based on cost plus a profit be compared with those based on a central-

(Continued on page 127)

NEW! FALK Screw Conveyor Drive

U.S. and Foreign Patents Applied For

—the drive our customers asked for

Our customers helped us design this new unit. We sent our men into the field to find out what our customers needed in a screw conveyor drive—then our engineers designed a new drive that offers the maximum of service, versatility, operating economy and long life. Here are some of its outstanding features:

A COMPLETE DRIVE: Saves engineering and assembly time. Six sizes to cover entire range—each with these ratios: — 4:1, 9:1, 14:1 and 24:1. Bolts to any standard trough end—eliminates trough end bearing. Eliminates drive shaft wobble. Efficient FALK single helical gears.

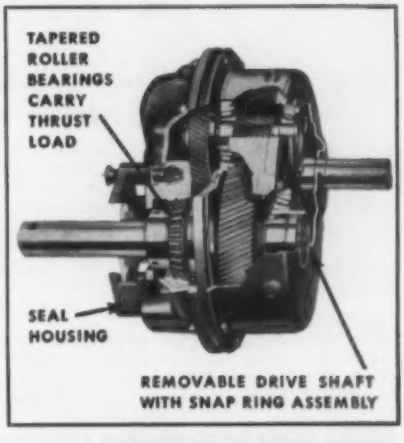
SEAL HOUSINGS: Choice of seals (neoprene or leather lip, felt or waste) to accommodate material conveyed. Space between trough seal and unit seal prevents conveyed material from reaching unit seal.

REMOVABLE DRIVE SHAFT: Snap ring assembly permits easy removal. Five sizes, from 1½" to 3 7/16".

TROUGH END: Can be fastened to any standard trough. Eight sizes, from 6" to 20".

ALL-STEEL MOTOR MOUNT: Saves costly engineering and installation time and costs; no motor plates to design or fabricate. Motor can be mounted in virtually any position. Pre-drilled to accommodate NEMA standard motors ½ to 30 HP.

AN IMPORTANT ECONOMY: Buy only what you need—the basic reducer alone, or with trough end and/or motor mount. For detailed information, contact your Falk Representative or Distributor—or ***write direct for Bulletin 7106.***



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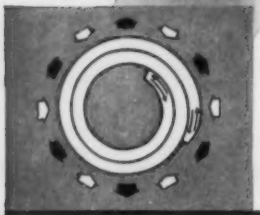
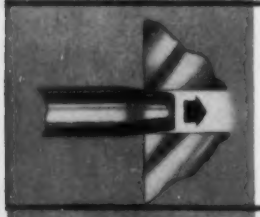
SPIROL - the spring pin made with Low-Cost Non-Heat-Treated Metals

Nickel stainless steel SPIROL pins are used as corrosion-proof fastenings on "Moen" one-handle mixing faucets. SPIROL pins can be made with *lower-cost*, non-heat-treated metals — stainless steel, brass, and ordinary copper — because stress is evenly distributed throughout the spiral coils, giving *full radial spring action*, with no flexing concentrated along a "hinge" line.



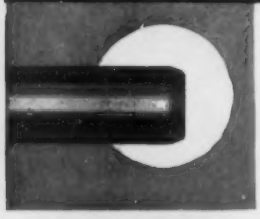
SHOCK RESISTANCE

High resistance to shock and vibration permits use of "medium duty" SPIROL pins in the majority of applications. Heavy and light duty SPIROL pins also available in stock.



WIDER HOLE TOLERANCES

Both plus *and* minus hole tolerances are allowed because spiral construction permits greater flexibility in expansion and compression. The wider hole tolerances eliminate precision reaming requirements, reduce drilling rejects, cut costs.



PERFECT CHAMFER

A. Smoothly rounded radius where chamfer meets shank eases insertion into hole. No sharp break to "bite" and resist insertion. *B.* Chamfer angle is precisely designed to offer minimum thrust resistance and maximum compression leverage.

MINIATURE PINS — SPIROL is the only spring type pin available in these miniature diameters: 1/32" — .039" — 3/64" — .052". Unique spiral cross-section retains flexibility and strength in smallest sizes. Other standard sizes up to 1/2" diameter.

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On this Dart "Mine Buggy" a compactly-designed Funk transmission provides multiple speed control and doubles as a drop box, thus saving the cost of a 3-stage gear box or a fixed chain drive.

And a Funk Revers-O-Matic Drive, equipped with torque converter, allows the buggy operator to change direction of travel with foot lever only.

Another example of how FUNK MODULAR POWER UNITS can be economically combined — in an unlimited number of arrangements.

Let FUNK solve *your* power transmission problem.

FUNK MFG. CO. Box 577-D Coffeyville, Kansas

government decision? Our prices reflect transportation cost from source, theirs do not. Who is to say which method of pricing is correct?

The compulsion to compare Soviet and American facts and figures has become a parlor game, and a highly inaccurate one. I have been faced with the necessity of making such comparisons myself, and have found again and again that my hearers reached conclusions I did not intend. These conclusions were often based on personal bias of the individual or over-active patriotism, but often were just plain misunderstanding.

Take the simplest case, the ruble in terms of the dollar: The official exchange rate is four rubles per dollar, but the tourist gets ten. My own observation is that 8-10 is about right in terms of what the dollar will buy. Which number should be used—or should the basis be days of work to buy various items?

The Soviet economy is based on the old law of supply and demand: items in short supply are priced very high. Thus, an automobile is prohibitively expensive, and any comparison with the American situation is ridiculous. Clothing is costly, too; transportation and simple food are not. Thus an incautious or biased observer can give a false picture either way. It is almost impossible to make fair comparisons of private-enterprise and government-operated economies.

Or take industrial growth. Russian figures are based on gross output, so parts of a given product may be counted several times—as ore, as shaped metal sections, as components,

(Continued on page 128)

". . . Oh, what's the use? . . ."

IT'S HERE—

The specific hydraulic hose assembly, coupling or fitting for your application!

Write For Anchor Catalog No. 595

When you have a problem in fluid power transmission, it's a safe bet that you can find its solution in an Anchor catalog. If not there, consultation with Anchor's engineers, with all their years of hydraulic experience, will be sure to bring the right answer.

We cannot say that the Anchor Line of hose assemblies, couplings and fittings is complete because it never will be. But we like to boast that if Anchor doesn't make it, it isn't being made!

And you can be sure that if it carries an Anchor trade mark—the quality and workmanship is of the highest.

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Stalwart Announces

SILICONE SPONGE RUBBER...

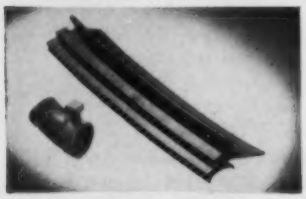
in extruded and calendered shapes

Exclusive new processes produce cross sections, lengths and densities to your specifications

Here is important news for designers in the appliance, aircraft, electronics and other industries! A unique process developed by The Stalwart Rubber Company now enables silicone rubber to be extruded and sponged in complex configurations or calendered to close tolerances to meet customer specifications. Here are the facts . . . Stalwart extrudes silicone sponge parts in 1/16 to 8-inch dimensions in lengths up to 300 feet. Calendered sheets are produced in widths up to 36 inches. These silicone sponge parts resist sunlight, ozone, and aging as well as temperatures ranging from −160° to +500° F. Stalwart also mass-produces all types of precision parts from natural and synthetic rubbers.

Send today for your copy of the new Stalwart Catalog.

Cell sizes range from very coarse to fine with open or closed cell-structures.



Silicone sponge extrusions can be combined with solid silicone rubber extrusions.

Calendered and extruded silicone sponge shapes can be covered with heat-resistant fabric.

Another first by

STALWART RUBBER COMPANY

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PLANTS in BEDFORD, OHIO and JASPER, GEORGIA.

and as final products. This is perfectly correct, but it does not compare with a figure based on non-repetitive counts.

Thus Allen Dulles of the CIA shows that Soviet production is only 40% of ours, not the 50% they claim. Both figures may, paradoxically, be correct—depending on whether American or Soviet prices and values are used.

Or again, consider the frequently silly statistics comparing workmen in the two countries. Most comparisons are really direct comparison of incomes —no allowance for vast differences in rent, medical service, income tax, and standard of living. Our people definitely live better, but the Soviet worker spends 5% or less for rent (compared with 15% here), nothing for medical care, and a maximum of 13% for income taxes. Our own statistics on prices of these products do not include city sales taxes and like elements of cost added later which the Russians do not have. And most statistics do not make any allowance for quality—high in American goods, low in Russian.

Even the budgets of the two countries cannot be compared. The Russian budget includes *all* expenditures —local and national, even medical and dental expenses; ours does not. So ours appears much higher in the percentage spent on defense—and the Russians capitalize on the apparent fact. Ours also shows much less spent on education, and the Soviet makes hay again. Most of the world—and most Americans—forget that education here is financed largely by state and local budgets and by private payments, not by federal funds.

As a matter of fact, the Russian propaganda posters in New York made capital of the low USSR income tax and predicted its impending demise—but failed to mention the offsetting Soviet heavy sales taxes on consumer goods. (On this point, Khrushchev is guilty personally of semantic sleight-of-hand in his speeches.)

Russian unemployment — officially non-existent—includes summer farm workers, those who leave one job and cannot immediately find another, and those who are "not busy" because of poor planning such as over-supply of the wrong kind of specialists or excess of high-school graduates in their home

(Continued on page 133)

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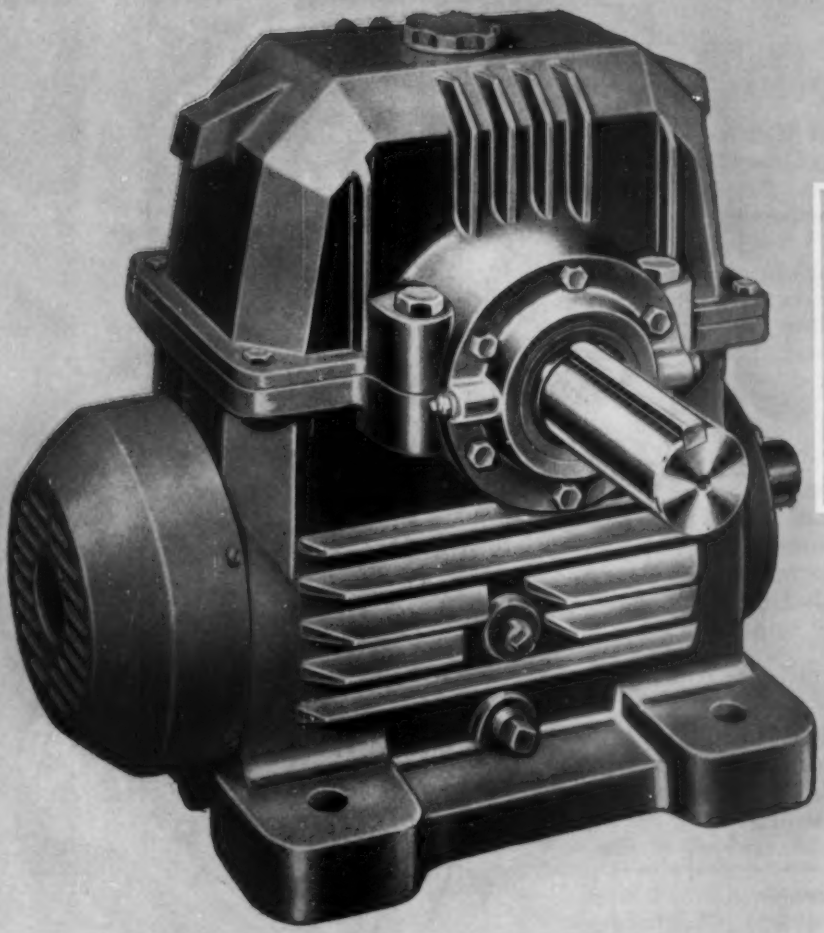
SPEED REDUCERS

De Laval Announces All New Line of Single Reduction Speed Reducers



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fan cooled 5" through 12" center distance
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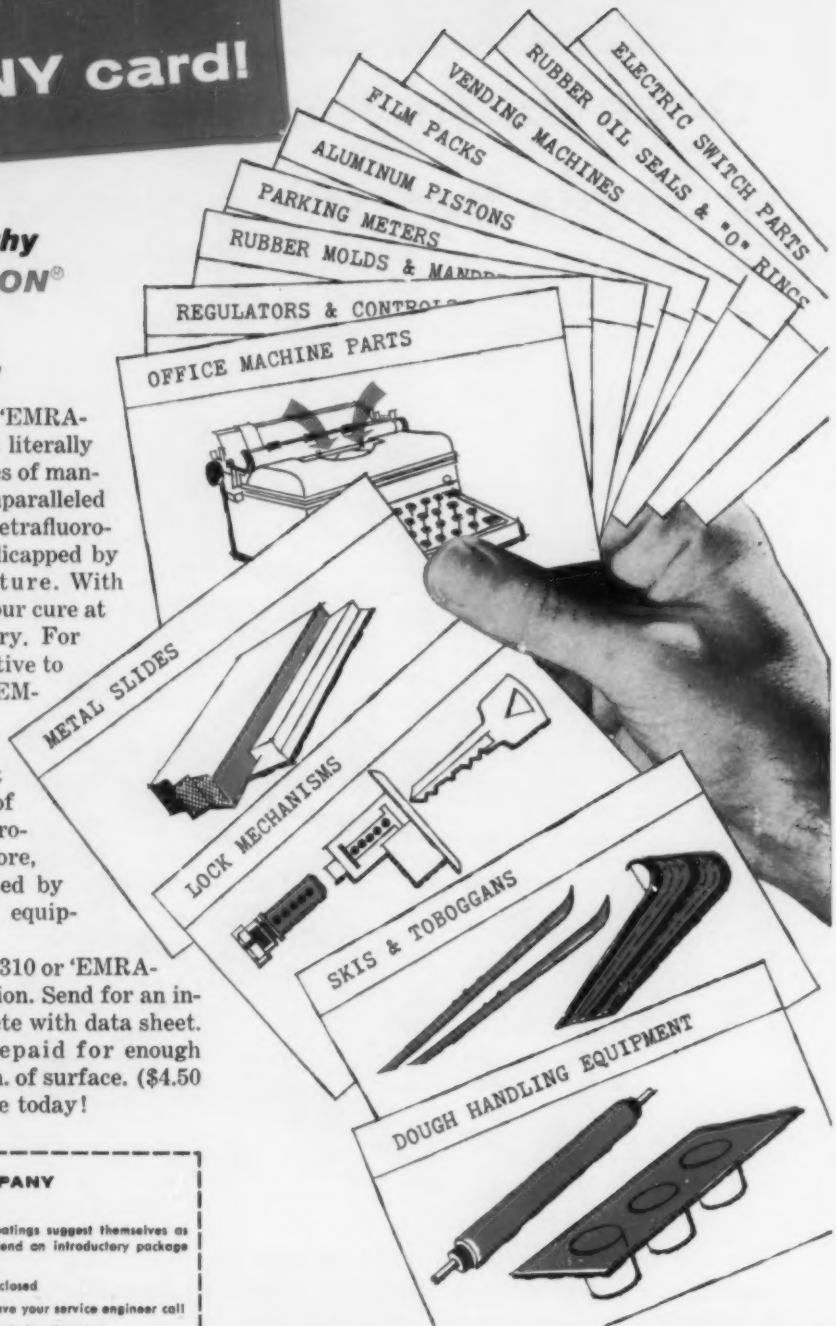

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APPLICATION:

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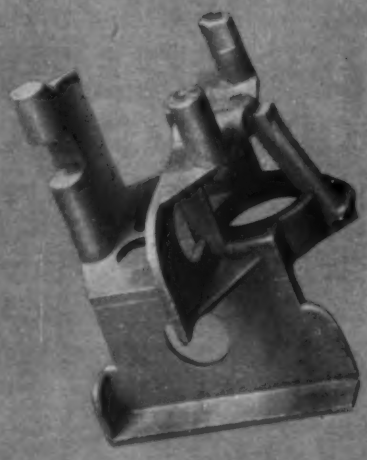
Is your new design complex?



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When the production people tell you it will be too costly to machine...

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When function calls for a tricky shape but the intended service makes you specify, a hard, strong, tough-to-work alloy...

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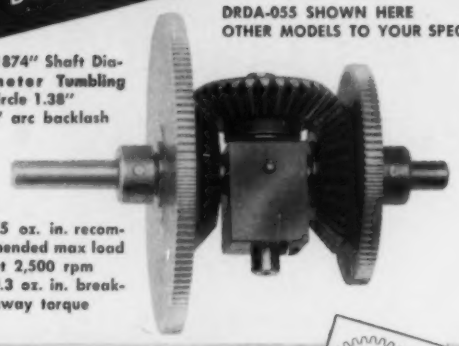

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- Cast Iron Base; 20-inch spread. 1⅛" steel glides.

Other White Room chairs with lacquered plywood seat and backrest.

FREE TRIAL Use an AJUSTRITE chair for 30 days without obligation. Prove to yourself the many advantages AJUSTRITE offers in comfort, utility and economy. Write today—we'll do the rest.

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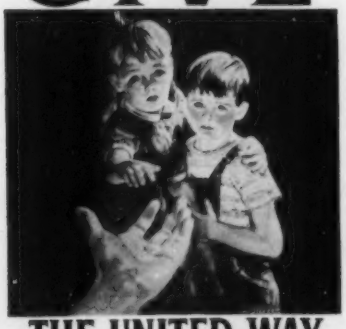
areas. We include such figures; they brush them aside as unimportant or non-existent. Yet letters in their press continue to prove that unemployment exists there as here.

All these elements are pointed up by a recent statement of Dr Edward Teller, "father of the hydrogen bomb" (at least in the West—remember Popov). He points out that at the end of World War II, the US was first in everything. Now he feels *there is not a shadow of doubt that the USSR will be the unquestioned leader in science within ten years.* This thought has been expressed before by dozens of other scientists, some crying "wolf," some not. But Teller adds the point that *we can do nothing today to stop this occurrence.* He feels that we can regain leadership later if we work at it—but lose it we will.

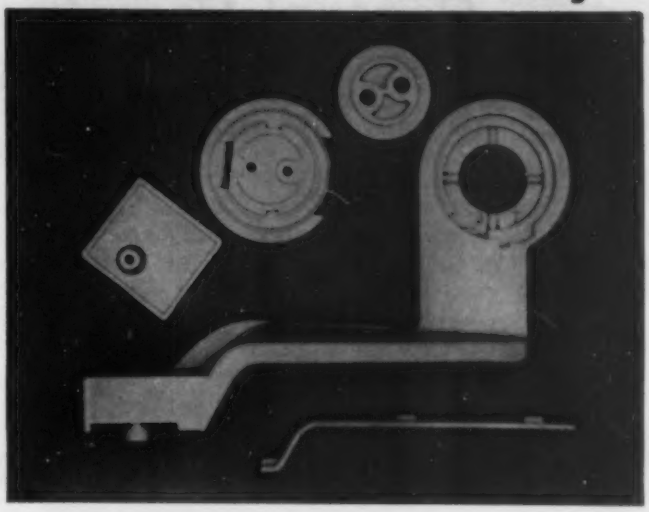
His reasons are interesting. He points out the much greater respect accorded scientists and engineers in the USSR, and the broad willingness to understand and appreciate technology. But here, the layman doesn't appreciate it, and there is no incentive (or whip) to learn it. We produce mainly for the masses, not for technological advance. Thus the technologist finds a chasm between himself and his fellows, which both sides build. We need time to fill that chasm — which takes time — time which we do not have. The Russians filled theirs long since by fiat. They have the advantage of organization, we of freedom. Which philosophy leads the world tomorrow will depend on whether or not we, as individuals, can prove our combined superiority over their mechanized state. —EJT

GIVE



THE UNITED WAY

POLAROID specified dimensional accuracy

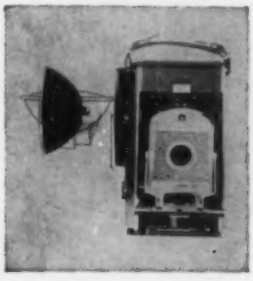


and got it from CONSOLIDATED

Both dimensional accuracy and fine appearance were essential requirements in the production of this camera flash attachment for Polaroid. Naturally, mold planning and construction were of utmost importance in such a critical job. Precision and timing had to be built into the mold design. Three different molds were necessary to produce the five separate pieces which form one synchronized unit.

In assembling the unit, all parts had to be kept in perfect alignment; no warpage or twist was permitted. For appearance's sake, it was necessary to locate mold parting lines on the natural edges of the pieces.

This flash attachment unit represents the type of molding challenge Consolidated welcomes. We appreciate the opportunity to quote on any molding – complicated or simple.



The Polaroid Bounce Flash Bracket (Model #292), with swivel-type flash gun clip, permits the taking of both horizontal and vertical pictures without removing the gun to change its position.

For more than 80 years we have been filling exacting plastics orders for the nation's blue chip companies. Before you discard any design you feel can't be molded in a plastic, call Consolidated.

CMP

"Your Blueprint in Plastics" Since 1874

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Cherry St., Scranton 2, Penna.

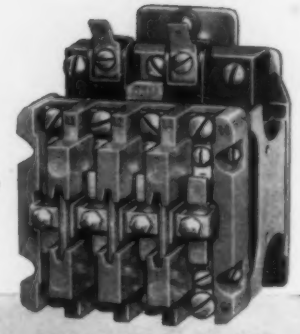
Send for your free copy of our new 20-page Facilities Report.

ESSEX ENGINEERED

This Complete RBM Control Family

is specially engineered for the air conditioning industry

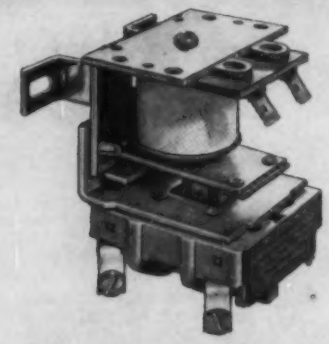
When RBM specially engineered its first air conditioning control, it quickly recognized the industry need for not just one . . . but for a *complete family*. So RBM has done the job. Now there is a single source for *all* magnetic air conditioning controls . . . each one meticulously engineered for its application. What's *your* requirement? See RBM.



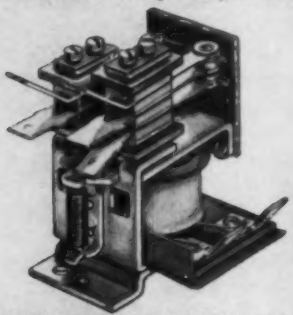
TYPE C—30, 40, 50 AMP. 2-3-4 pole 30 amp.—600 volts. 2-3-4 pole 40 amp.—230 volts. 2 pole 50 amp.—230 volts. Same mounting holes and coils for all ratings and pole forms.

ALL PRICED TO MEET THE NEEDS OF VOLUME USERS

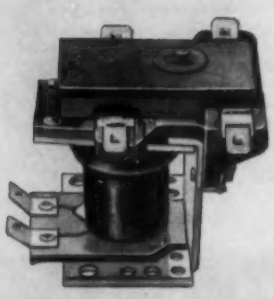
SERIES 128000 POTENTIAL STARTING RELAYS For starting single phase capacitor start compressors.



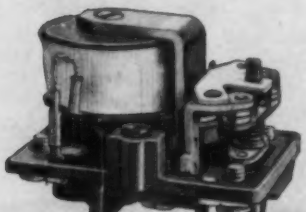
TYPE 80 CONTROLLER Specific design for nominal 3 HP or 3-ton single phase compressors.



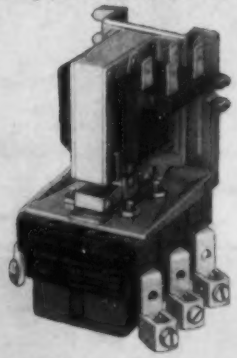
GENERAL PURPOSE RELAY 98000 Series AC or DC. Permits engineering short cuts lowering your "finished product" cost.



TYPE 75 Low cost power relay. Dependably handles up to 6000 W. at 240 V., resistive load per pole. Compressor rating 2 poles, 18 amp. running, 90 amp. lockea rotor at 250 volts.



SERIES 129000 SHUNT TYPE RELAY—SPNO, SPNC or NO-NC For standard commercial voltages. Other coils available for special application. For heater, fan control, aeneral circuit switching, etc.



TYPE S—30—40 AMP. Low cost. Small size. Exceed rigid requirements of industry's largest users.

Consult your local RBM Product Application Engineer or Write for Bulletins 1030A, C-8, 1010A, 1060 and C-10.

RBM

RBM Controls Division

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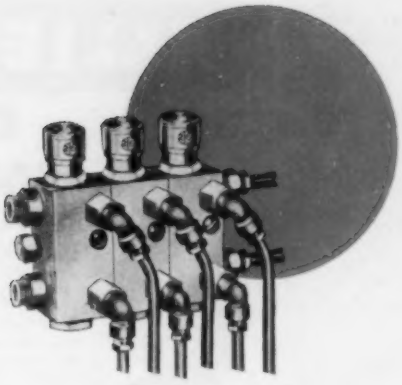

Type II Accumatic Valves are fully automatic. Completely sealed for *clean* lubrication of power shovels, cement kilns, conveyors—any indoor or outdoor installation. For all fluid oils and most lighter greases. Available in four sizes to fit a wide range of applications.

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SAFELY, ACCURATELY, ECONOMICALLY

An Accumatic Centralized Lubrication System delivers measured amounts of lubricants at proper intervals, to provide a better lubricant film on all bearing surfaces. Assures completely accurate lubrication, *even while machine is in operation,* with no interruption in production. Reduces lubricant consumption and prolongs service life of each bearing. Machines with many bearings or dangerously located bearings are lubricated from one central point . . . vital high-precision machines receive proper lubrication at all times.

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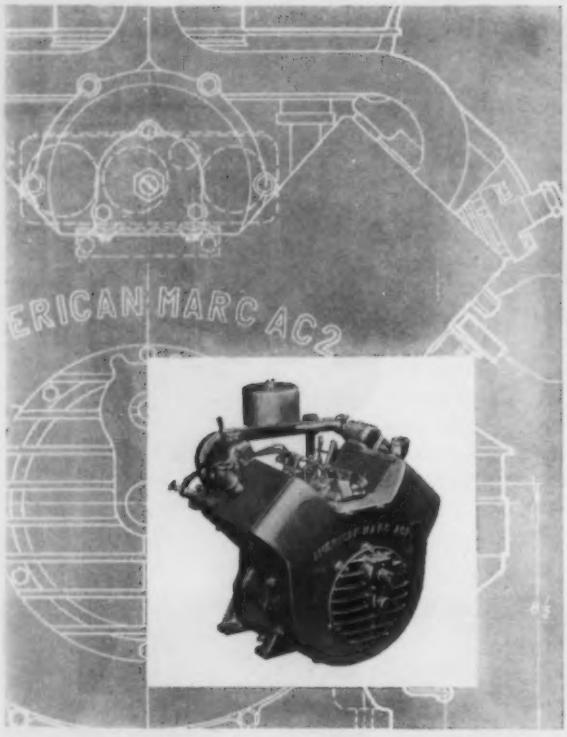

The American MARC blueprint for **PRECISE POWER**

American MARC offers the design engineer a wide range of precision-built **PRECISE POWER** equipment from which to choose—manufactured for strict adherence to operating specifications—designed for a dependable flow of continuous power under all operating conditions. Fully guaranteed, all-American built American MARC products include:

Super rugged ultra-lightweight Diesel and natural gas engines, 10 to 20 HP, air and water cooled, for an almost infinite variety of low horsepower applications... **PRECISE POWER** engineering holds engine RPM to 3% maximum variation, assuring unwavering output regardless of varying load conditions.

Custom built generators, ranging from 500 watts to 100 KW, in static excited and permanent magnet types, available in AC, DC, 400 and 60 cycle models.

Generator sets, incorporating field-proven American MARC Diesels, from 2½ to 7½ KW for every electric power requirement. Engineered for **PRECISE POWER**, American MARC generator equipment features voltage and frequency regulation control to values of less than ¼ of 1%, keeping transient disturbances to a minimum in both duration and magnitude. Superb production craftsmanship assures operating dependability.

Our nation's Armed Services, demanding the ultimate in dependability, have standardized on American MARC **PRECISE POWER** Diesel equipment... equipment now available to you for your design applications. Our nationwide network of distributors assures you prompt service and parts dependability.

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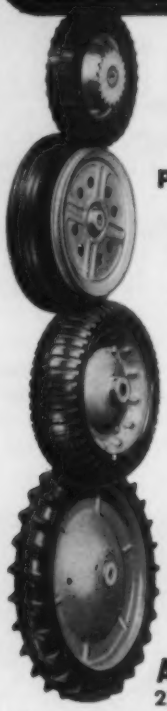
DRIVE WHEELS

SIMPLIFY YOUR PRODUCT PROPELLING PROBLEMS!



ALL TYPES—MANY SIZES:

● Let field tested and proven ALLIED Drive Wheels solve your propelling requirements. Big selection of high production stock types and sizes, at favorable prices!

SPROCKET DRIVE WHEELS—7 to 10" dia. for low speeds and weights.

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WASHER DRIVE WHEELS—6 to 12" dia. for walking speed only.

COTTER PIN DRIVE WHEELS—many sizes.

VARIATIONS AT SMALL COST

Slight modifications of ALLIED stock Drive Wheels can be made with minimum or no tooling cost—to meet O.E.M. precise requirements in production quantities!

FREE ROLLING WHEELS TO MATCH

ALLIED offers matching companion wheels for all types and sizes of Drive Wheels—with choice of nylon, ball, or sleeve bearings. Hub caps available for all wheels too!

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Free Technical Bulletin on Surface Measurement

gives all the meat of ASA Standard B46.1-1955 on surface roughness, waviness and lay, plus helpful supplementary material. Arranged for easy reading and convenient reference. Includes these sections:

- Basic definitions—with profile records of typical surfaces.
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DESIGN ABSTRACTS

Multi-anvil, Wedge-type, High-pressure Generator

Apparatus for generating pressures in excess of 100,000 atmospheres is described. Based on application of force by an anvil against each face of a solid polyhedron.

"Compact Multi-anvil Wedge-type High Pressure Apparatus," Lloyd, Hutton and Johnson. Journal of Research of the National Bureau of Standards, Section C, July-Sept 1959, Washington 25, DC.

Piston Gage for Pressures Below 0.5 in. Hg

A tilting, air-lubricated gage for differential pressures up to 0.5 in. of Hg is described, which is reported to provide resolution of better than 1:100,000, full scale.

"A Tilting Air-lubricated Piston Gage for Pressures Below 0.5 in Hg," U O Hutton, Journal of Research of the National Bureau of Standards, Section C, July-Sept, 1959, Washington 25, DC.

Testing for Research, Design and Improvement

Twenty-two articles discuss planning, designing, interpreting, determining what to test, scale-model testing, analog simulation, breadboarding, testing functions. Twelve testing case histories are also included.

"Testing for Research, Design and Improvement," Control Engineering, Sept 1959, 330 W 42nd St, New York 36.

Mechanical Properties of Metals in Design

How to use test results of such properties as fatigue, selective corrosion, brittle fracture and other major causes of failure is described. Tensile strength is also discussed, along with hardness and various types of impact testing procedures.

"Significance of Mechanical Properties of Metals in Design", D. Birchon, Admiralty Materials Laboratories. Engineering Materials and Design, Aug-Sept 1959, Drury House, Russell St, London W C 2, England.

Blind Riveting

Types of blind rivets, riveting processes and equipment, joint designs and strengths are discussed. Fifty design

(Continued on page 139)

SMOOTHIE!

Approximately 3 Times Actual Size

General Electric NE-2M and NE-2P permit easier wide angle viewing

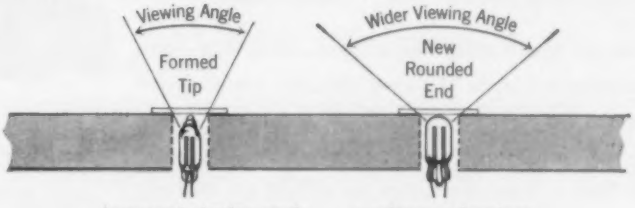
The new General Electric NE-2M (standard brightness) and NE-2P (high brightness) Glow Lamps are real smooth indicators.

1. The rounded end gives you a clear, distortion-free lamp when viewed end-on.

2. The new shape permits the lamp's electrodes to be placed extremely close to the end of the bulb, thus providing a wider viewing angle. (See diagram)

3. "Hot or cold", both types dress up appliances, electronic equipment, and indicator panels.

4. When placed beneath translucent material, the lighted area produced has a more uniform appearance.



Improved viewing angle . . . a primary advantage of having electrodes nearer the end of the lamp.

The General Electric NE-2M and NE-2P are currently available in limited quantities. Both lamps are described more completely in the engineering data sheet, #3-9289 Want one? Write: General Electric Co., Miniature Lamp Dept. M-911, Nela Park, Cleveland 12, Ohio.

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WALDRON COUPLINGS....

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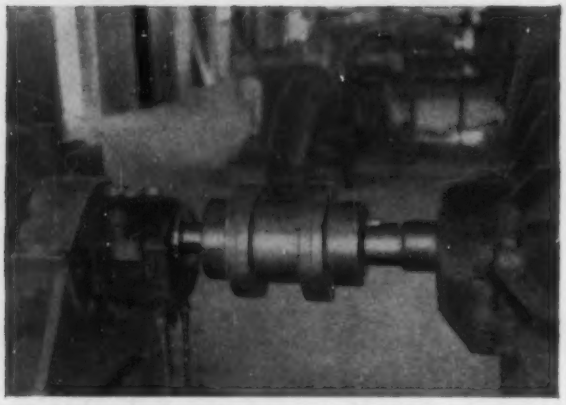

Waldron standard coupling on crude oil pumps on 20" line from Wyoming to Indiana.

John Waldron makes a complete line of standard couplings. They are all designed to transmit maximum power smoothly and safeguard the connected machines from the effects of misalignment which occur during operation. And, outside of periodic lubrication, the couplings never need maintenance. Hence, once these couplings are installed they will run continuously over the years (often outlasting the equipment they couple) with minimum care and maximum efficiency.

Waldron can stand behind these claims because their standard couplings are made of forged steel and are machined under controlled conditions. The two, one piece cover sleeves and spacer function as a single unit with no flexible metal parts to bend or break. Couplings are oil tight and dust and moisture free.

There are plenty of rough bore standard couplings on the shelves at Waldron and other locations throughout the country ready for immediate delivery. Finished bored couplings may be ordered to customer specifications.

JOHN **WALDRON** CORPORATION

Subsidiary of Midland-Ross Corporation

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PROBLEMS?

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RUBBER, PLASTIC AND SILICONE EXTRUDED AND MOLDED PARTS

Have your problems—heat, cold, color, oil resistance, and close tolerance—solved by experts.

Two plants with complete facilities for designing, compounding and finishing, to your specifications.

Convenience: Branch offices in leading cities for personal service.

Products finished to Commercial and Government Specifications

Write today for additional information

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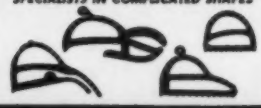

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Simplify Design Problems

Uneven loads will not sway, tip or tilt because off-center load is evenly distributed on both springs. Variable ratio springing adjusts self to road conditions. Deflection rate changes automatically to produce exactly right capacity to properly balance spring tension with load. Lower center of gravity without sacrifice of clearance. Only four bolts to mount . . . no assembly required. Just two friction bearings with renewable friction inserts control spring action.

PRIOR PRODUCTS, INC.

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checkpoints are described and drawings detailing clearances and allowances, design practice, weatherproof joints and other details are included.

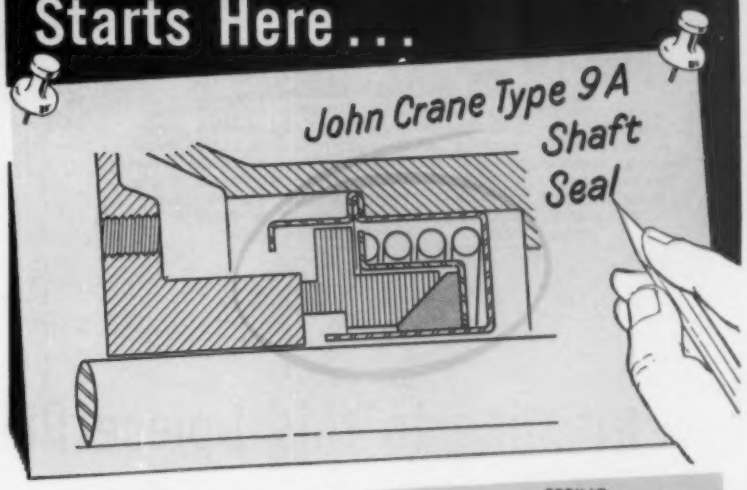
"An Engineer's Guide to Blind Riveting Practices", C E Heilig, Jr, Pop Rivet Div, United Shoe Machinery Corp. American Machinist, Sept 7, 1959, 330 W 42nd St, New York 36.

Ballbearings at High Speeds and Extreme Temperatures

Endurance tests made with 20-mm bore ballbearings prelubricated with polyester felt rings saturated with di (2-ethylhexyl) sebacate with additives are reported. Tests were also made with greases for comparison. Speed was 10,000 rpm; temperatures 80 F to 400 F. Tests were also made of special bearings of same size made of high-speed tool steel, prelubricated at 450 F, unlubricated at 650 F (5000 rpm).

"Friction and Endurance of Prelubricated and Unlubricated Ballbearings at High Speeds and Extreme Temperatures", H S White. Journal of Research of the National Bureau of Standards, Section C, July-Sept, 1959, Washington 25, DC.

Sealing Corrosive Liquids Starts Here...

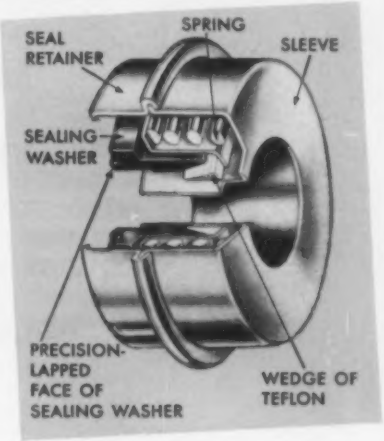


This cartridge-type shaft seal designed for the production line is engineered for:

(1) positive sealing of many industrial chemicals and solvents (note the Teflon* sealing wedge);

(2) leakproof handling of inflammables and toxics;

(3) operation over a wide temperature range from −120° to +500°F., pressures to 150 psi.



It offers the Original Equipment Manufacturers these important advantages:

(1) low unit cost through mass production;

(2) fast, one-piece installation through cartridge construction;

(3) equal efficiency on both low or high speed applications, because seal does not rotate with shaft.

The 9A Shaft Seal can be of stainless steel, monel, brass or other materials adapted to stamping and forming—depending on the service requirement.

Get full details. Request Bulletin S-205-3 from Crane Packing Co., 6445 Oakton Street, Morton Grove, Illinois *(Chicago Suburb).*
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

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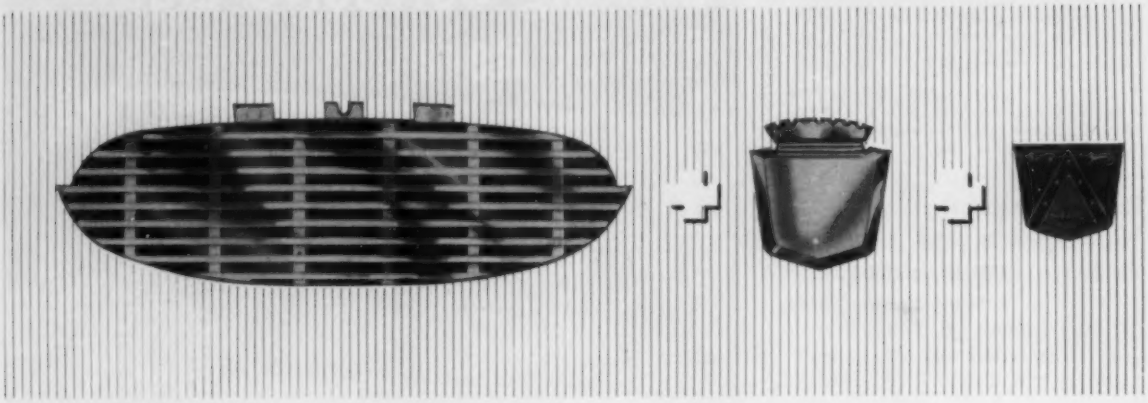
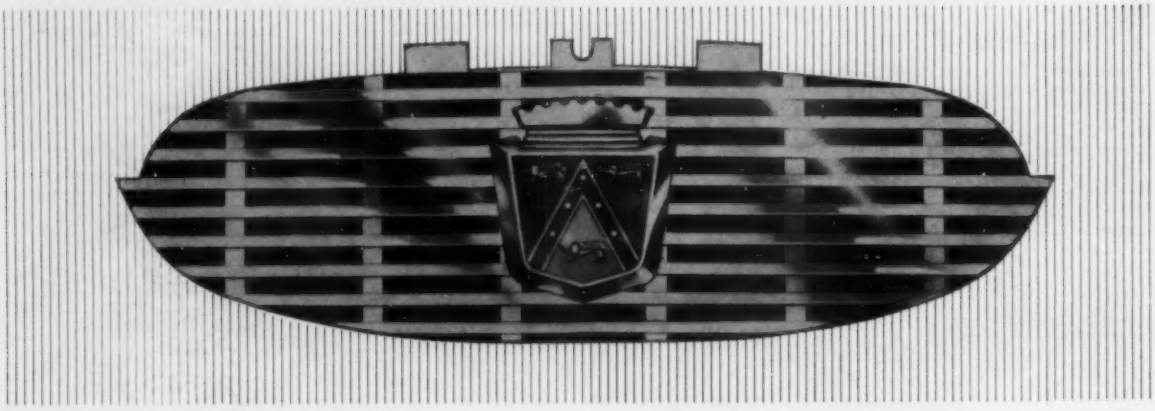
Cost of 3-part metal-plastic medallion cut **57%**



by switching to this 1-piece PLEXIGLAS molding



Proof that you can save with **Plexiglas**

Everybody recognizes the economics of using a single molded plastic part rather than a multi-part assembly. But when you mold the complete unit of PLEXIGLAS® acrylic plastic, the *saving* is just one of many outstanding advantages you gain.

Obviously, assembly time is eliminated. There are no metals to corrode, tarnish or pit. All decorative effects are protected from harm on the underside of the molding. The surface is mirror smooth and continuous. Color range, metallic effects and accurate reproductions of trademarks are almost unlimited. And there's built-in resistance to breakage and weathering.

The above example is based on estimated costs . . . and incidentally, saved this company thousands of dollars.

Perhaps you can put PLEXIGLAS to work for your company . . . at a big saving. Write for information and molding help.

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In Canada: *Rohm & Haas Co. of Canada, Ltd., West Hill, Ontario.*

Chemicals for Industry

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

Hundreds of good reasons why Clark "PM" Relays are worth waiting for

The word is out about the most complete, integrated line of control relays available today.

If your shipment of Clark "PM" Relays has been delayed, please be patient. There's a very good reason. Seems like *everybody* wants them.

It all began when Clark first announced the completion of a *full line* of "PM" Relays. We were literally snowed under by an avalanche of orders.

We're happy to report, however, that our manufacturing facilities have been expanded to meet the demand and we're rapidly catching up—even though the avalanche continues.

Is it any wonder when you consider the many advantages the Clark "PM" Relay line offers: modular construction that makes possible integrated uniformity, compactness and flexibility . . . neater, more uniform panels . . . the greatest possible use of every square inch of valuable space.

Is it any wonder also, when you consider that *every* relay in the Clark "PM" line is manufactured with the same careful attention to detail that has long made Clark *"the standard of quality"* for industrial control.

No time-saving production short cuts are worth sacrificing this quality, even in the face of the tremendous demand created by customer preference. In fact, we're sure our customers wouldn't have it any other way.

Your Clark Controller sales representative or distributor will be glad to give you more reasons why Clark "PM" relays are your best control relay buy—well worth waiting for. Contact him or write direct to Clark Controller. 9R2

The **CLARK CONTROLLER** *Company*

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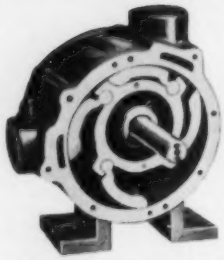
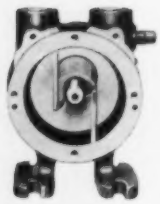
Higher Vacuum . . . Suction . . . Pressure with Smaller Pumps!



Metal Vanes take up their own wear



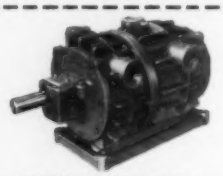
4-VANE TYPE. Vacuums to 20" Hg.; pressures to 15 lbs.; displacement to 162 c.f.m. Vanes hinged to pistons maintain continuous sealed contact with cylinder walls by centrifugal force. Small pistons, large air chambers, greater capacity.

2-VANE TYPE. Vacuums to 29.9" Hg.; pressures to 20 lbs.; displacement from 2.4 to 105 c.f.m. Automatic Vane adjusting lever forces wear-resistant steel blades to cylinder walls, preventing sticking or binding, maintaining positive vacuum or pressure.

COMPACT INTEGRAL PUMP and MOTOR

27" Hg. Vacuum
20 psig. Pressure

Two models, 3.6 c.f.m. and 7.2 c.f.m. Uses Leiman 2-vane pump. Fan-cooled for continuous operation. Automatic oiler, over load protection, ball bearings. Inlet filter and outlet separator for oil-free air.



DOUBLE CYLINDER MODEL

Provides both vacuum (suction) and pressure simultaneously. Needs only one motor—saves space. Models up to 20" Hg. Vacuum, 15 psig. pressure.

Save space, weight, horsepower — improve performance — get "lifetime" dependability with

LEIMAN Rotary Positive AIR PUMPS

Over 70 years' air engineering at your service

The exclusive Leiman hinged metal vane design provides 2 to 3 times more air space per weight and size of pump. Maintain original pump ratings and trouble-free operation for years because simplified design has fewer moving parts—all parts are durable cast iron and steel (not composition) — no gaskets or packing—quiet operation—little or no maintenance. Every pump tested before shipment. Over half million installed.

WRITE for 16 page Catalog, plus Application Book showing dozens of "how-to-do-it" blueprints.

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Established 1887

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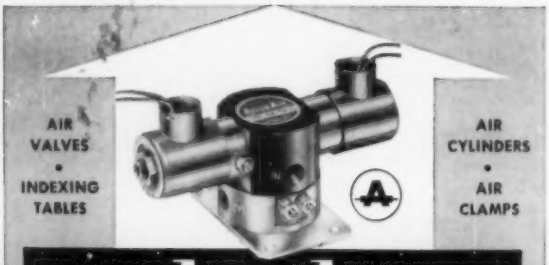

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AIR CYLINDERS • AIR CLAMPS

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*Using their own products helped a lot, but working 16 hours a day was the only answer.

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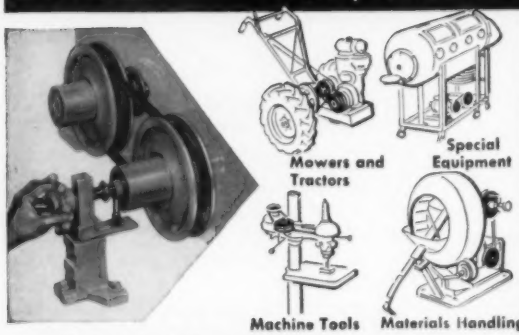

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NEW BOOKS

Cryogenic Engineering

RUSSEL B SCOTT. D Van Nostrand Co Inc, 257 Fourth Ave, New York 10. 6 x 10, 368 pp. $5.60.

The author of this admirable first book on the practical aspects of cryogenics intended it "primarily for the reader who is unfamiliar with low temperature." Even though he has largely met his objective, bringing to bear some 30 years' experience with NBS, it must be reported that the practical handbook of cryogenic engineering remains to be written.

Scott's treatment of insulation problems, liquefication, and separation of gases is straightforward and couched in unsophisticated thermodynamics. His discussions of the comparative value of different insulation systems and how to compute their effectiveness is particularly well done. His two chapters on properties of cryogenic fluids and structural materials are packed with useful tables. It is on the design details of crucial hardware that his book is disappointing. The designer entering this field will soon desperately need specific information on points like these, touched on but lightly in this book: proper weld-joint design, methods for calculating vacuum-shell stiffening, a comparison of tank-suspension systems, methods for calculating thermal stresses, and a realistic evaluation of those commercially available components (valves, seals, pumps, bearings) that can be adapted to low-temperature service.

This is a dilemma only partly of the author's own making: Although his experience has been primarily with laboratory equipment, he is primarily hamstrung by the secretive attitude of most of the industrial concerns doing large-scale cryogenic work. This kind of information is thought to be precious as crown jewels. Until this state of mind changes, book as important as Mr. Scott's are bound to fall short of the mark. —FRP

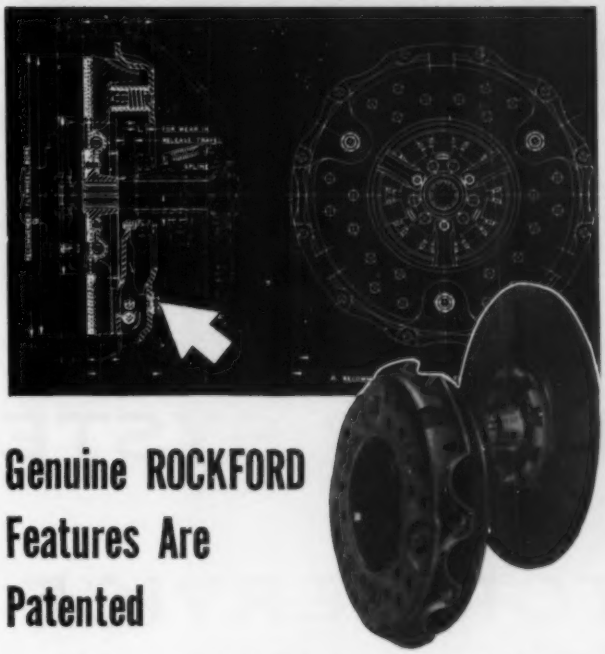
Digital Computing Systems

SAMUEL B WILLIAMS. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 9¼ x 6¼, 230 pp. $7.75.

Here is the story of what's behind the blinking lights and whirring drums

(Continued on page 147)

ROCKFORD



Genuine ROCKFORD Features Are Patented

Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

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Power Take-Offs

Speed Reducers

Features of the ROCKFORD RT CLUTCH are covered by patents and patents pending. To give your product the full advantages of these ROCKFORD developments, it is necessary to specify ROCKFORD CLUTCHES.

Don't be fooled by any "copy" or "imitation." The Genuine ROCKFORD CLUTCH is what YOU want. The ROCKFORD CLUTCH has the needed skill and long years of experience behind it.

Let our engineers help you determine the type and size clutch best suited to help improve the power transmission control in your next model.

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

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CLUTCHES

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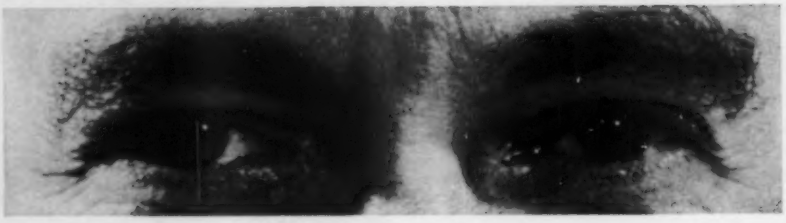
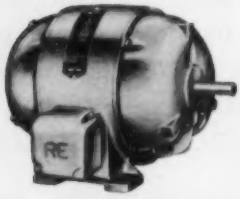
WOULD OFFER AN



HONOR SYSTEM

MOTOR SERVICE POLICY?



15-Year-Old Service Policy Takes the Word Of Any Local Electric Motor Service Shop of Your Choice

Here is another indication of Reuland quality... and the extent to which our company stands behind its products. It is based on a trust in people, and a trust in Reuland workmanship. It has met the test of time, and captured the acclaim of Original Equipment Manufacturers... and *their* customers.

Whether *your* company is an O.E.M., or a User, the Reuland Honor System Service Policy can be your passport to uninterrupted machine operation. If you are tired of delays while service responsibility is determined... if you would like to talk to a motor company that can look you straight in the eye and be measured, your experience with Reuland could be a revelation.

A free copy is available on request. Explains the simple steps to take. Shows how Reuland's unique philosophy of doing business permits it to offer the industry's only Honor System Service Policy! All company officials should have a copy. We'll mail yours promptly.

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... all in lightweight aluminum frames!

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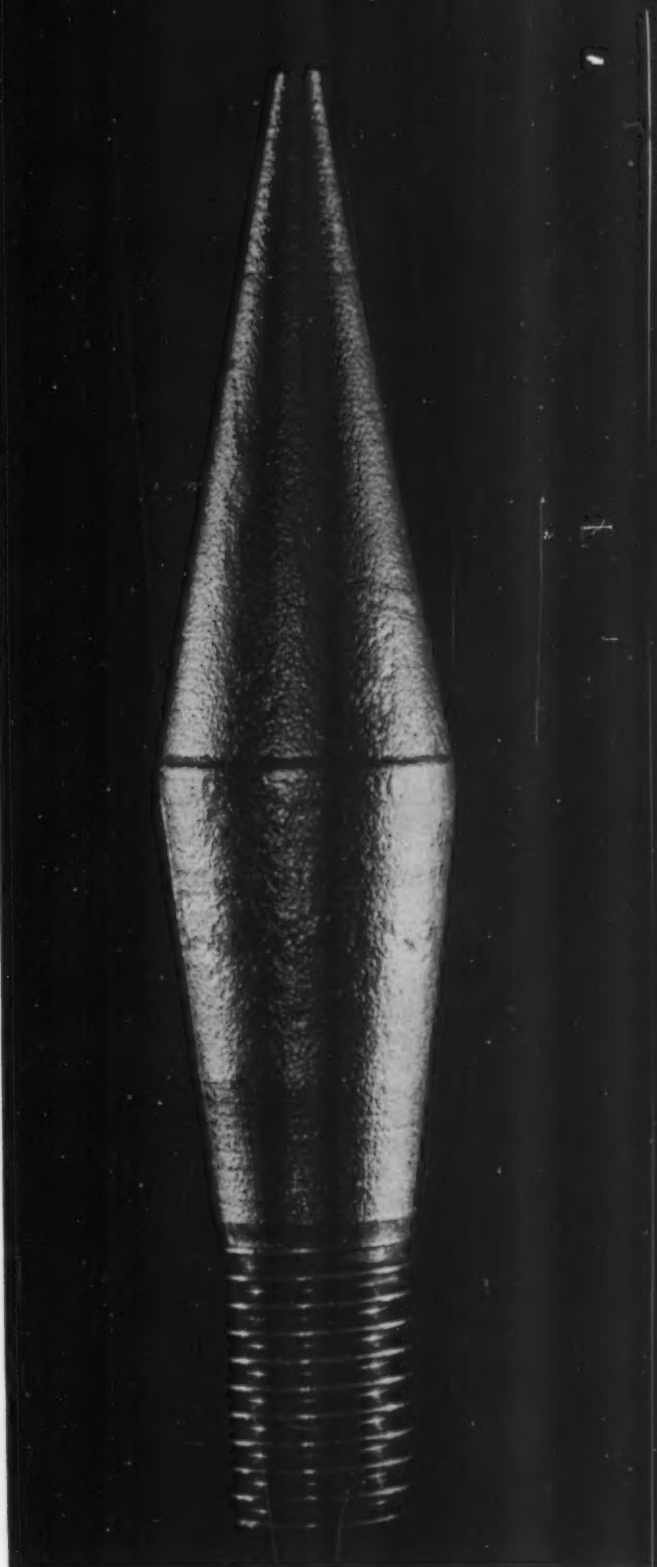
For important Reuland Engineering data refer to Sweet's 1959 Product Design File, section 5a

Not a New Missile

it's a special fastener



It looks like it's ready to blast-off from Cape Canaveral. But see the threads? They give it away for what it really is—a fastener. And a very special kind, made by Bethlehem.

Our customer uses this special fastener as the point in a grip hook for steam log loaders. It's got to be strong and hard and tough. That's why we hot-forge it from a special alloy steel and heat-treat it. Other manufacturing operations: trimming, descaling, threading.

Forgings, bolts, nuts, rods, stampings—Bethlehem makes every kind of steel fastener specialty. Headed, threaded, pointed, bent, or slotted. Machined, punched, or drilled.

The nearest Bethlehem sales office will give you full details. Or write to us at Bethlehem, Pa.

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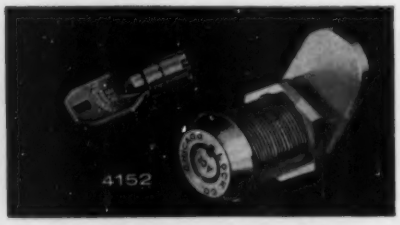
Maximum Security at a Price You Can Afford

Every model in Chicago Lock's extensive line offers sure protection at reasonable cost. Every model is a marvel of precision engineering, compact design and rugged reliability.

They're handsomely styled, too and they operate smoothly under virtually all conditions. No wonder more and more design engineers specify Chicago Locks for an amazing variety of applications.

If your next project calls for a lock, investigate the Chicago line. You'll find a model that's perfect for your purpose and priced to keep costs down.



Chicago Lock's famous ACE line features the exclusive ROUND keyway for maximum security.

Write today for your catalog showing, in detail, the entire Chicago Lock line.

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Buying Better Die Castings—No. 1

Paramount Die Castings Help Reeves Pulley Co. Make Variable Speed Drive

Three castings are supplied by Paramount to Reeves for the end shields and dial wheel on the Reeves Motodrive.

Size 100 Reeves fractional h.p. Vari-Speed Motodrive with infinite variable output speed from 2.86 to 4660 rpm. Size 100 is one of a full line of Reeves Motodrives for speed control on ¼ hp. through 40 hp.

Paramount can help solve your design and production problems.

If you use die castings, it pays to investigate Paramount's complete die casting service. Their designers, sales engineers, and modern tooling and production facilities offer you an ideal die casting service.

Zinc, Aluminum and Magnesium Die Castings.

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A guide to Designing for Die Castings and a visit to Paramount.

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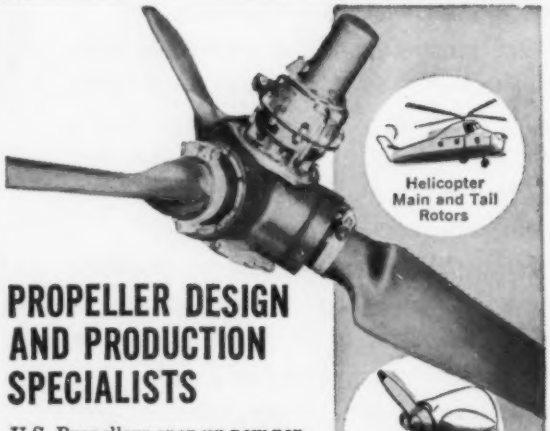

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1. WE STUDY THE FUNCTION

2. WE DESIGN THE RIGHT PART

3. WE RECOMMEND THE BEST ASSEMBLY TECHNIQUE

Smart designers are getting an assist from Milford—not only with basic design tips—but with a complete Assembly Analysis from drawing board to finished product.

For the answers to assembly problems . . .

. . . get in touch with Milford first!

THE MILFORD RIVET & MACHINE CO.

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CIRCLE 219 ON READER SERVICE CARD

of modern computing machines. It's written for readers with an engineering background but assumes neither a thorough grasp of mathematics nor an up-to-date knowledge of electronics. In 10 chapters, it describes the active elements of electronic computers, from input to output, and the underlying operating principles of each. There are over 150 pictures and drawings of representative samples of available equipment and components. Logical design, programming and other aspects of how the machine is put to work are also discussed.

Operations Research—Methods and Problems

M SASIENI, A YASPAN, L FRIEDMAN. John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 6 x 9¼, 316 pp. $10.25.

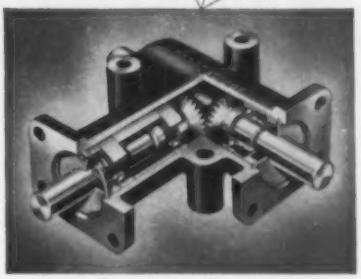
Many books explain or discuss operations research; this one proposes to teach it . . . through a somewhat unique arrangement of material. Each chapter, complete in itself as a teaching unit, contains an exposition of the theory and techniques of a particular problem area, followed by several completely solved problems illustrating these techniques. At the end of each chapter are a number of problems for the reader to solve—with answers and, in some cases, hints to help clarify particularly difficult problems.

The first chapters give the background: probability and sampling. The remaining chapters discuss specific areas of operations research: inventory,

(Continued on page 151)

"Charlie, here, has more experience with missiles than anyone else on our staff."

NEW 2¼ HP ANGLgear® HELPS SIMPLIFY YOUR 90° DRIVE PROBLEMS



Hardened bevel gears and antifriction bearings insure smooth, trouble-free operation. Completely enclosed, permanently lubricated ANGLgear requires little or no maintenance.

Addition of the new 2¼ hp size to the ANGLgear line makes it easier than ever to solve your 90° power takeoff problems with this standardized right-angle drive. You can now specify ANGLgear in any one of 16 different stock models, offering power ratings from ⅓ to 5 hp, with choice of 1:1 or 2:1 gearing and 2 or 3-way shafting.

Compact, high capacity ANGLgear offers you several distinct advantages over V-belts or chains and sprockets. Featuring 5-way mounting, it is easier to design into your power transmission systems. Incorporating positive bevel gear drive, it eliminates slippage and backlash problems. Completely enclosed, it presents no safety hazards. Permanently lubricated, it requires virtually no maintenance. And not the least important, ANGLgear invariably costs less than other types of 90° drives.

See our literature in Sweet's Product Design File or contact your local distributor.

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a new, improved ALODINE for aluminum

Cost Saving, Time Saving ALODINE 1200S Pre-Paint Treatment Protects Aluminum Best!

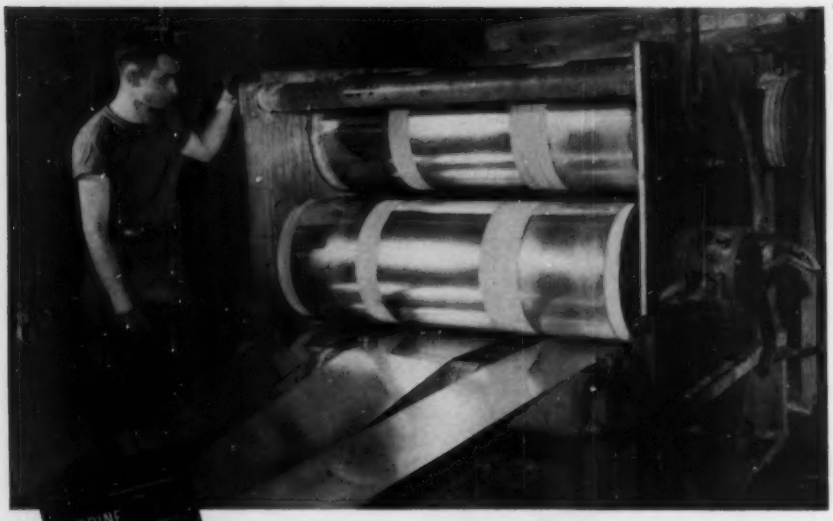
IN LESS TIME—ALODINE 1200S provides increased chemical activity for dramatic reduction in processing time . . . up to 50% in most cases! You get far faster processing than ever before, with the same high quality protection!

WITH LESS EQUIPMENT—You can install an ALODINE 1200S system quickly and conveniently, *without resorting to mechanical bath maintenance!* That means no dangerous, time consuming checking routines with the possibility of bath contamination always present!

AT LESS COST—ALODINE 1200S can be processed through continuous dip in the same time cycle other conversion coatings require for continuous spray lines! This dip technique reduces initial equipment costs, slashes maintenance costs to a minimum and allows aluminum fabricators to utilize conversion coatings more frequently for a wider range of product applications! Whatever the application method—brush, dip, continuous strip or spray—ALODINE 1200S may be the answer to your production problems.

FOR MORE FLEXIBILITY—Most important, its ease of operation, safety in use and versatility enables ALODINE 1200S to answer one of the most perplexing problems inherent in providing corrosion protection and paint bonding qualities for aluminum—the problem of constant, uniform quality. ALODINE 1200S is qualified under Government Specification MIL-C-5541.

Investigate cost saving, time saving ALODINE 1200S today! And whenever you have a chemical finishing requirement for aluminum—any type of aluminum—there's an ALODINE process available to protect or decorate the metal, and anchor the paint finish more securely.



Typical ALODINE 1200S strip line installation at ALSCO, INC. Strip from aluminum coil is fed into Alodine processing baths where it is cleaned, rinsed, deoxidized, rinsed, coated with ALODINE 1200S, rinsed and given a final acidulated rinse. Strip is then rewound, roll coat painted, roller formed into final shape, backed, inspected and packed for final shipment.

Write for Bulletin 1424A describing use of Alodine for aluminum fabrications of all types.

AMCHEM

ALODINE 1200S

another chemical development of **AMCHEM PRODUCTS, INC., Ambler 20, Pa.**
(Formerly American Chemical Paint Co.)

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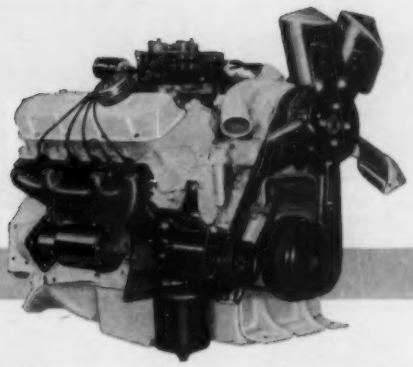

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FORD INDUSTRIAL ENGINES POWER THE ARMY'S NEW 5-TON LIGHTER — *the LARC-5*

The Larc-5, designed and built by Ingersoll Kalamazoo Division of the Borg-Warner Corporation

Compact Ford engine saves weight and space on the super-efficient Larc-5

Built to speed supplies from ship to shore, the Army's "LARC-5" (*L*ighter, *A*mphibious, *R*esupply, *C*argo) can travel over sea, sand, swamp and rough terrain to deliver its cargoes directly to inland combat supply points. Aluminum-fabricated, the LARC-5 has far greater cargo capacity and maneuverability than the amphibian it is to replace.

The heart of this lightweight but rugged craft is a performance-proved Ford 534-cu. in. Industrial Engine . . . precision-engineered to give maximum efficiency with a minimum of attention. Like all Ford Industrial Engines, the 534 provides a higher power-to-weight ratio than ever before possible.

Whatever your Ground Support Equipment requirements, there's a Ford Industrial Engine to meet your needs. Today, thousands of Ford-powered Ground Support Units are in service around the globe.

Here are just a few of the many types of Ground Support Units now powered by Ford Industrial Engines:

- Jet Starters
- Runway Sweepers
- Aircraft Tow Trucks
- Ground Support Air Conditioners
- Ground Support Air Compressors
- Multi-Purpose Servicing Units

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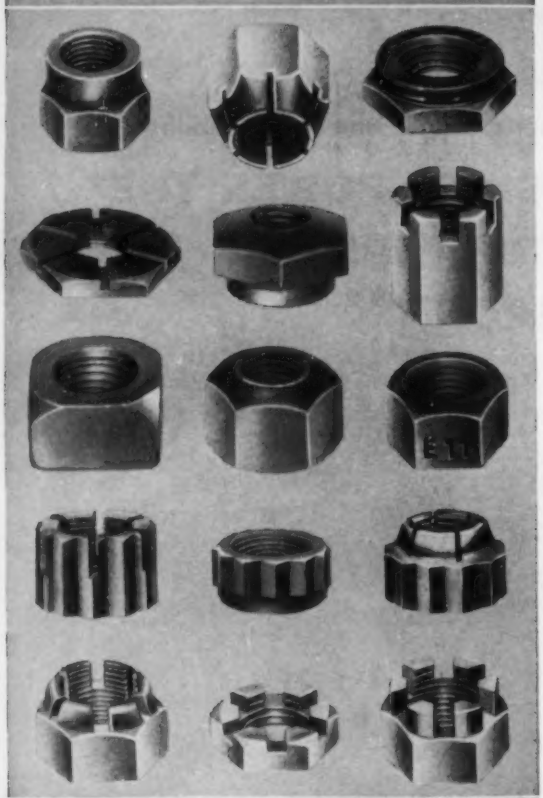
SPECIAL NUTS

to specs. 7/16"—4 1/4" cross flats

special machines + large stock of material × years of experience = speedy deliveries high quality low prices



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*12 Pointer Standards, sizes: 1/4" to 3/4"—brochure on request

NATIONAL MACHINE PRODUCTS

*Manufacturer of Standard and Special *12 Pointer and Hexagon Nuts . . . "Huglock" and "Marsden" locknuts.*

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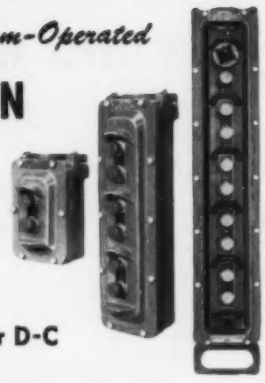
For Hazardous Locations

Heavy-Duty, Cam-Operated

PUSH-BUTTON STATIONS



600 Volts
A-C or D-C

● The Euclid Electric & Mfg. Co. (Madison, Ohio) has added a complete new line of Pendant Push-Button Stations for all applications that necessitate NEMA Types 7 and 9 enclosures to meet hazardous-location requirements. Designed for heavy-duty applications, these cam-operated Stations are rated 600 volts, a-c or d-c. They are available from one to five speed-points in each direction for a total of eight circuits to provide for practically an unlimited number of different sequences of operation.

Sturdily constructed to withstand hard usage and abuse, their small cross-section permits comfortable, non-fatiguing, one-hand operation. Where required, a bottom holding handle can be supplied. The dense cast-aluminum enclosure can be readily opened for inspection of the silver-to silver contacts without disturbing any wiring. The conduit hole is threaded and a double-suspension cable hanger is provided.

Extra features include heavy-duty, control-circuit toggle disconnects, pilot lights, selector switches, and maintained-type contacts.

ASK FOR BULLETIN 2017

THE EUCLID ELECTRIC & MFG. CO.
MADISON, OHIO

THE EUCLID ELECTRIC EUCLID AND MFG. CO., MADISON, O.

waiting lines, game theory, linear programming, sequencing and dynamic programming. The mathematical level is not exceptionally sophisticated but the authors do assume a working knowledge of differential and integral calculus.

Advanced Energy Sources and Conversion Techniques

Seminar proceedings sponsored by Dept of Defense in cooperation with California Institute of Technology and the University of California, under auspices of US Army Signal Corps. PB151461. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8¾ x 11, 256 pp. $4.

Fuel cells, nuclear batteries, and thermoelectric conversion systems, as well as more conventional power sources are covered in this big, nicely printed volume that contains the proceedings of a seminar held in California late last year. Although a collection of separate speeches, the coverage is remarkably complete. It should be noted that not all of the talks presented at the meeting are represented in this volume. Seven of the 36 were classified and are contained in a separate volume, available through the "customary channels" by those who "can establish a need to know."

Physical Metallurgy

C ERNEST BIRCHENALL. McGraw-Hill Book Co, 330 W 42nd St, New York 36. 6 x 9, 323 pp. $8.50.

Physical metallurgy, simplified. There is no such thing, but this book accomplishes it better than others. Like the others on physical metallurgy it requires a background of college math along with knowledge of thermodynamic principles. But unlike the others it divorces the practical engineering aspects so that it can treat the fundamentals more simply. Very specialized and not for the average designer. Its up-to-date treatment of the subject, however, makes it an excellent text for those in materials R & D.

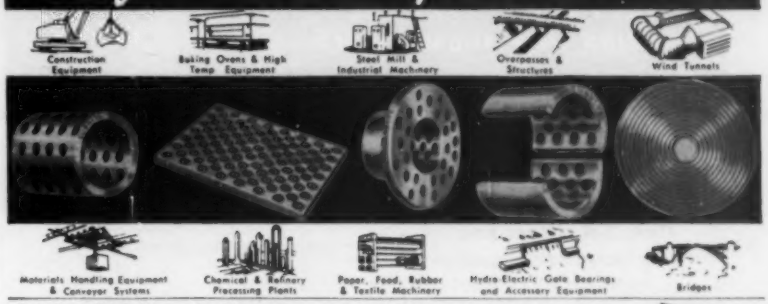
Sampling Inspection Tables

DODGE and ROMIG. John Wiley & Sons, Inc, 440 Fourth Ave, New York 16. 8½ x 11, 224 pp. $8.

This second edition contains a working set of scientific sampling tables based on the mathematics of probability. In addition it has a comprehensive collection of "probability-

(Continued on page 153)

ASSURED SELF-LUBRICATING SECURITY WITH LUBRITE® Self-Lubricating BEARINGS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Steel Mill & Industrial Machinery
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Paper, Food, Rubber & Textile Machinery
Hydro-Electric Gate Bearings and Accessory Equipment
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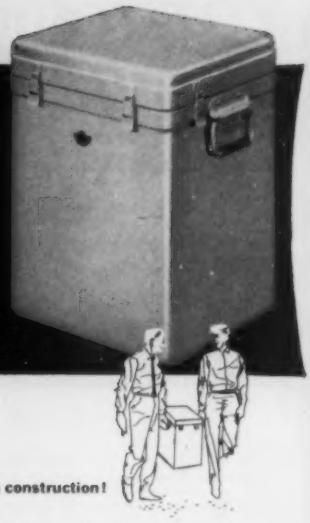

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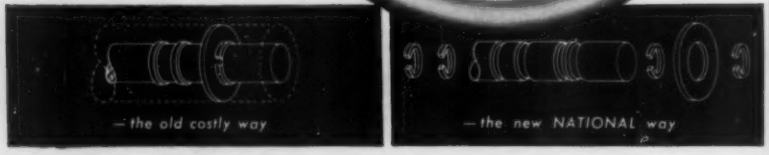

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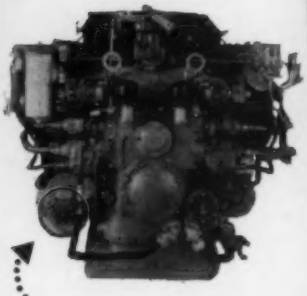

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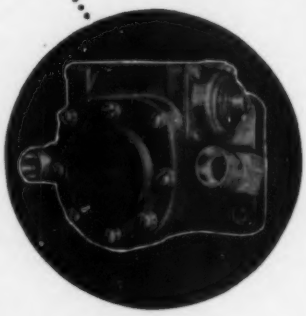

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CIRCLE 152 ON READER SERVICE CARD

of-acceptance" curves called operating characteristic curves. These can be used to determine just how particular sampling plans chosen from the tables will operate for all possible levels of presented quality, good or bad.

Complete set of OC curves are included for both single and double sampling, and also for a generalized set of single sampling plans.

A new chapter discusses the practical significance of OC curves. The revised edition also shows how the plans can be used in destructive inspection and gives pointers for making the best selection of a sampling plan. For use directly in the shop, this book stresses the minimizing of inspection costs, and provides procedures and forms that will be helpful to any inspection organization.

Precipitation-hardenable Stainless Steels

D A ROBERTS, D B ROACH and A M HALL, Battelle Memorial Institution. PB 151068, ASTIA AD 214194, DMIC Report 112. Defense Metals Information Center, Columbus 1, Ohio. 8½ x 11. 80 pp.

In the 700- to 1300-F range, mechanical properties of the more common materials begin to drop off; aluminum and magnesium alloys cannot be considered as structurals at all. The carbon and low-alloy steels here begin to overtemper and lose their hardened strength. Even ordinary stainless in the higher end of this temperature range begins to lose its

(Continued on page 155)

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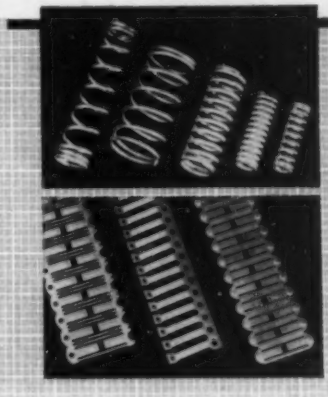

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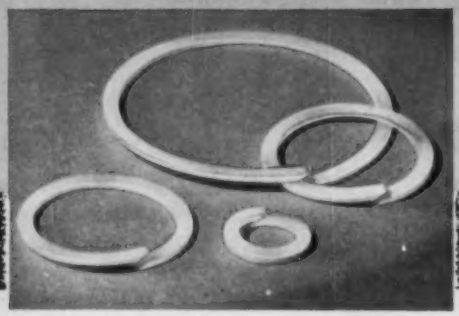

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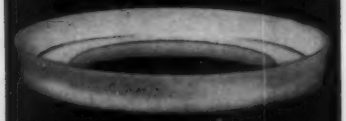
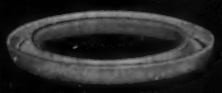
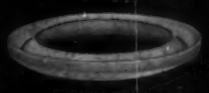


Style 310 Piston Cups



Style 614 V Rings



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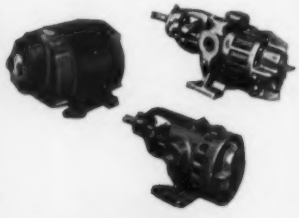

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rather low tensile properties. So, in recent years, a new class of precipitation-hardenable stainless steels was developed to fill the gap.

Properties for each specific steel differ widely but their chief assets include one or more of the following: high room-temperature strength, to 300,000 psi; retention of cold-worked properties—sometimes enhanced by aging; low-temperature age hardening that eliminates the drastic temperature gradients of quench-hardening and subsequent distortion; inherent resistance to atmospheric corrosion; oxidation resistance at elevated temperatures.

"Physical and Mechanical Properties of Nine Commercial Precipitation-hardenable Steels" compiles data obtained from producers of the material, so is not necessarily directly comparable. No attempt is made to evaluate the merits of the various steels or the validity of the test data. Nevertheless, this report provides a compact reference on all nine steels.

Only the optimum hardening treatments for these steels are listed. For a detailed discussion of metallurgical principles, see companion report, "The Physical Metallurgy of Precipitation-hardenable Stainless Steels."

Design Criteria for Cushioning Materials

KRAKOVER and OLEVITCH. PB 151720. Wright Air Development Center. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 42 pp. $1.25.

Although specifically directed toward packaging problems, this report provides definitive data on behavior of plastic foams, glass fiber mats, and other fibrous cushioning materials under dynamic load. It includes stress-strain curves and tabular data that should prove useful in design of instrument cushioning and for other equipment where acceleration and impact pose problems. Full title: "Investigations of Design Criteria for Cushioning Materials".

Basic Electronics

BERNARD GROB. McGraw-Hill Book Co, Inc. 330 W 42nd St, New York 36. 6 x 9. $6.50.

This is the first of a two-volume package presenting an introduction to the entire electronics field. It is written especially for the student who

(Continued on page 157)

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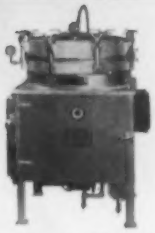

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has no background in electricity and little background in mathematics, and gives the essential principles of electricity, magnetism, and simple electric circuits. Although most of the book is on the level of elementary physics, it can be useful to an engineer who has been out of touch and wants a refresher. Covered are series-parallel circuits, resistors, batteries, electromagnetism, inductive reactance, filters, electron tubes, transistors and many other topics.

Appendix has electronic frequency spectrum data, FCC frequency allocations, universal time-constant graph for RC or RL circuits, resistor and capacitor color codes, circuit symbols.

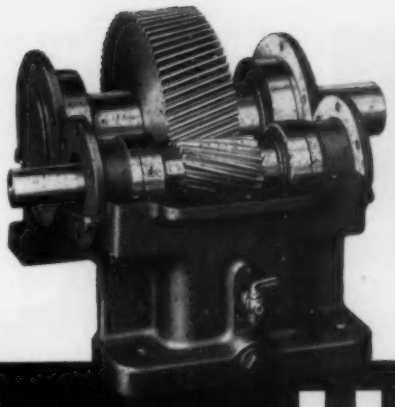
Energy Dissipation in Longitudinal Vibration

CHANG and GOODMAN, University of Minnesota. PB 151212 (WADC Technical Report 58-36). Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 40 pp. $1.25

The propagation of stress waves in long prismatic elastic bars has been studied extensively. Apart from their intrinsic interest as examples of one-dimensional elastic wave propagation, the results of these studies have had application in non-destructive material testing and in deep well drilling. Furthermore, the one-dimensional wave equations which governs the propagation of longitudinal stress waves in prismatic bars (at least in a first-order theory) also governs the propagation of torsional stress waves in rods of circular cross section, the dynamic behavior of tall structures,

(Continued on page 158)

"Let's cut out the brainstorming and get to work!"



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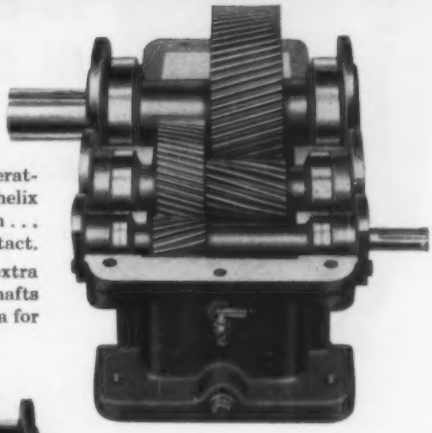
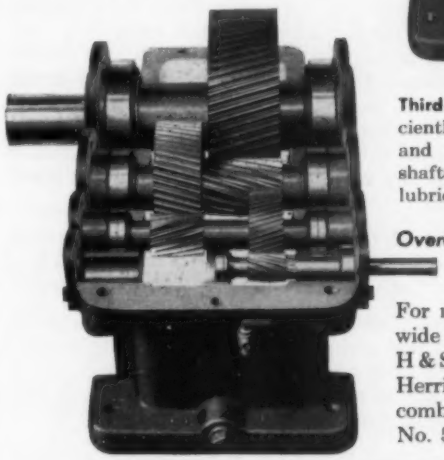


First—The helical gears are generated by H & S at the most efficient helix angle to insure smooth operation . . . several teeth are always in contact.

Second—Heavy-duty housings, extra bearing capacity and oversize shafts guarantee ample reserve stamina for the most exacting demands.



Third—Bearings and gears are efficiently splash lubricated, and dust and oil-proof seals on extending shafts keep out trouble—keep in lubricant.

Overall design conforms to AGMA specifications

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Gives Better Accuracy, Weight and Cost

Important advantages can often be gained by "designing in" bearings as a part of the unit in which they operate. A case in point is this hub assembly, produced and bearing-engineered by ITI.

Here, the two outer raceways and one inner raceway are formed in the hub and shaft; and the second inner ring – made separate to permit assembly – is close to a zero-tolerance fit. Compared to the usual design (using separate bearings), this construction gives (1) higher and more uniform accuracy, through elimination of 6 radial tolerances; (2) less weight and greater compactness, by eliminating 3 rings; and (3) lower total cost.

Other features include low running torque, labyrinth seals, high vibration resistance, and a dished hub held within .001" of the mathematically-specified contour.

In comparable ways, you too can benefit through our ability to design and produce bearings having unusual compactness or configuration, heat resistance, corrosion resistance, ultra precision, or other special properties. Let's talk it over.

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and certain electrical communication networks.

In this report a method is shown for obtaining a solution for the forced and free vibrations of a bar with terminal dashpot subject to arbitrary excitations and initial conditions. The general solution is then applied to a number of illustrative cases.

Influence of Shaft Deflection and Surface Roughness on Capacity of Plain Journal Bearings

RAVEN and WEHE. NASA TN 4-4 (National Aeronautics and Space Administration) Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 11, 57 pp. $1.50.

Shaft deflection is one of the many factors known to limit the load capacity of full journal bearings to magnitudes less than the infinite values predicted by hydrodynamic theory. This deflection produces an adverse alignment of journal and bearing that causes metal contact at the bearing ends and subsequent failure by seizure. Shaft deflection and roughness of the bearing surfaces are shown to be factors of first-order importance in limiting the load capacities of bearings. On the basis of the criteria presented, it is shown that the optimum length-diameter ratio of a bearing is reasonably predictable. Full title: "Technical Note D-4. Influence of Shaft Deflection and Surface Roughness on Load-Carrying Capacity of Plain Journal Bearings".

Evaluating Load Ratings for Roller Bearings

Mechanical Standards Board, American Standards Assn, Inc, 70 E 45th St, New York 17. 8½ x 11, 19 pp. $1.75.

For the first time, a uniform capacity rating system for bearings made by all manufacturers is available—full title: "American Standard Method of Evaluating Load Ratings for Ball Bearings". It covers uniform test procedures and statistical methods for determining load-carrying capacity, and expected fatigue life of both ball and roller bearings. Dynamic as well as static capacity of radial and thrust type bearings are included. In addition, the standard contains definitions of bearing life, basic load rating, equivalent load, basic static rating, and

(Continued on page 159)

4 Ounce Contact Force Makes Relays More Reliable

Contact force of 4 ounces per contact on 50 "G" models and 2 ounces per contact on 30 "G" models of "Diamond H" Series R and Series S miniature, hermetically sealed, aircraft type relays is one of the most important factors in their proven high reliability.

Though absolute reliability of any similar device is impossible to guarantee—a bitter fact of life recognized by all electronic engineers—close approach to this goal by the relays manufactured by The Hart Manufacturing Company is the basic reason they are found today on many of this country's headline-making missiles.

In addition to contact force far beyond that found on other relays, "Diamond H" relays have greater contact cleanliness. Self-contamination is virtually eliminated by a completely inorganic switch mechanism, as well as use of coil materials which will not dust, flake or out-gas.

Finally, the high degree of reliability that is designed into these relays is maintained in their manufacture by high quality workmanship and a stringent inspection policy at every stage.

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Engineering Thermodynamics

SPALDING and COLE. McGraw-Hill Book Co, Inc, 330 W 42nd St, New York 36. 6 x 9, 375 pp. $8.50.

This book gives the reader a thorough introduction to the fundamentals of thermodynamics. The important concepts of the science are emphasized in a readable but rigorous manner. The authors base their approach to the subject largely on the work of Professor J. H. Keenan.

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(Continued on page 161)

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Editor, *Product Engineering Design Digest*
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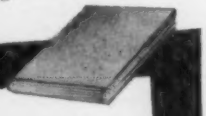

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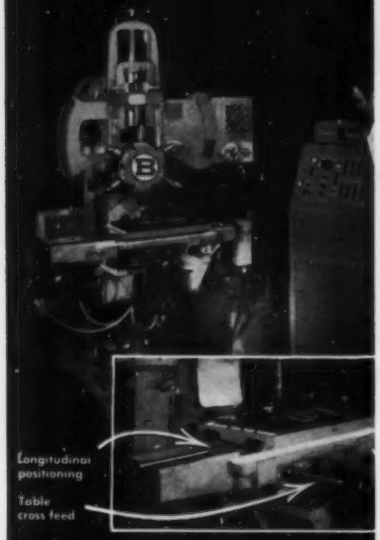

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Servomechanism & Regulating System Design

CHESTNUT and MAYER. John Wiley & Sons, Inc. 440 Fourth Ave, New York 16. 9 x 6, 680 pp. Vol. 1, $11.75

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Management's Mission in a New Society

Edited by Dan H. Fenn, Jr. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 5¾ x 8¾, 345 pp, $6.

This book is based on the proceedings of the 28th Annual Harvard Business Conference. It discusses what society expects of management, the role the manager plays today, and also presents a case study based on an electronics manufacturer's experience.

Heat and Mass Transfer Bibliography with Selected Abstracts

PB151517. Christian and Schiffman. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8¼ x 10¾, 167 pp, $3.

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Of Product Engineering published weekly with add'l issue in mid-Sept., at Albany, N. Y., for October 1, 1959.

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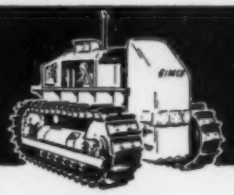

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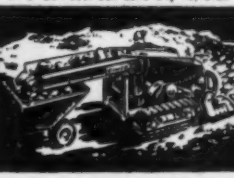

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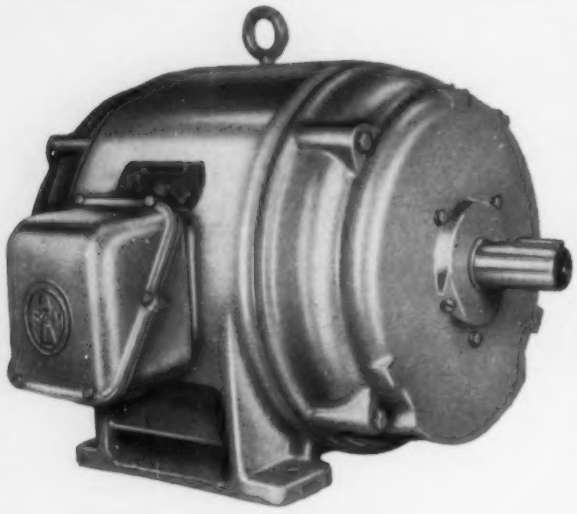

Spiro-duct double-end system: In standard motor shown, air enters shaft end and discharges between feet on conduit box side of motor. Conversely, air entering free end discharges opposite conduit box. In motor with conduit box located opposite to standard position, direction of air flow is reversed in relation to drive shaft location.

Spiro-duct moves cooling air in clockwise spiral direction, through space between stator core and motor frame.

Cools entire core and winding regardless of direction of rotation!

From the research and development laboratories of Fairbanks-Morse comes Spiro-duct cooling—the most effective design available for positive cooling of Dripproof motors—available now in F-M rerated KZK motors, in frames 364U through 445U.

Two completely independent paths for cooling air are provided in the Spiro-duct double-end system. All portions of the stator core and winding are thus assured equal cooling, regardless of direction of rotation.

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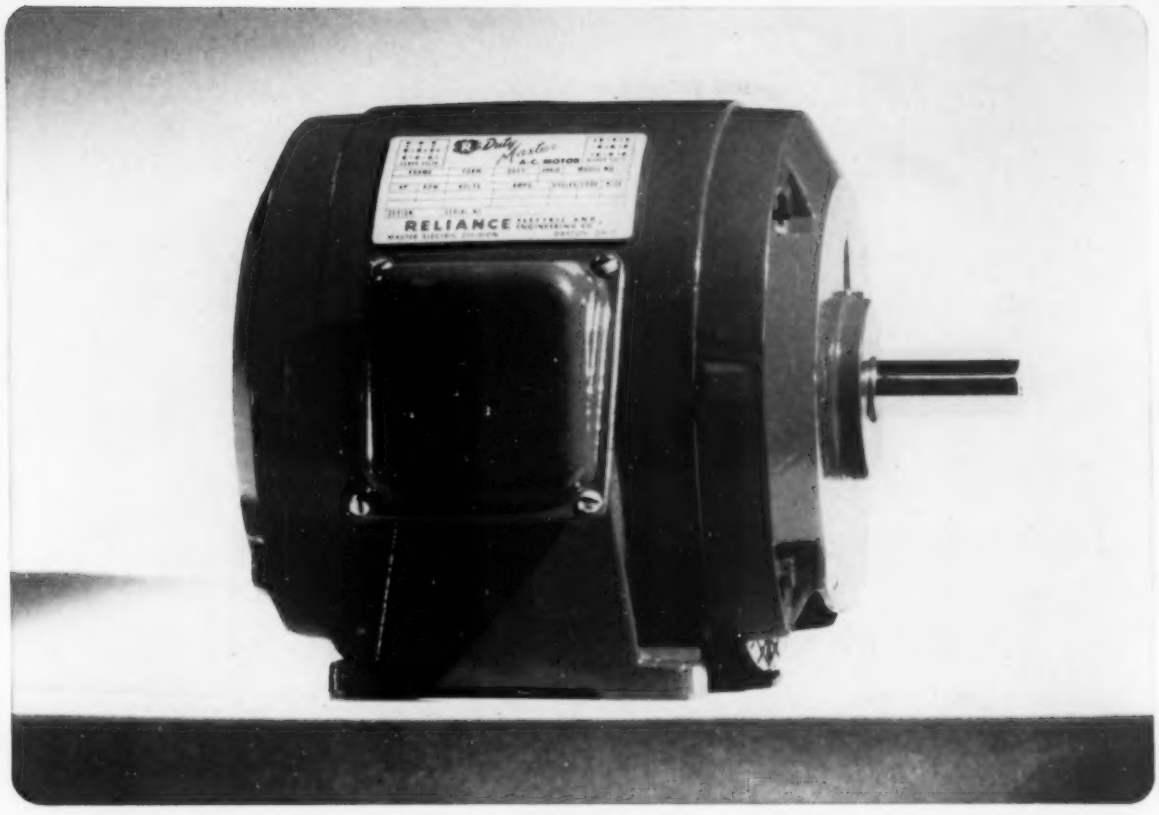

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